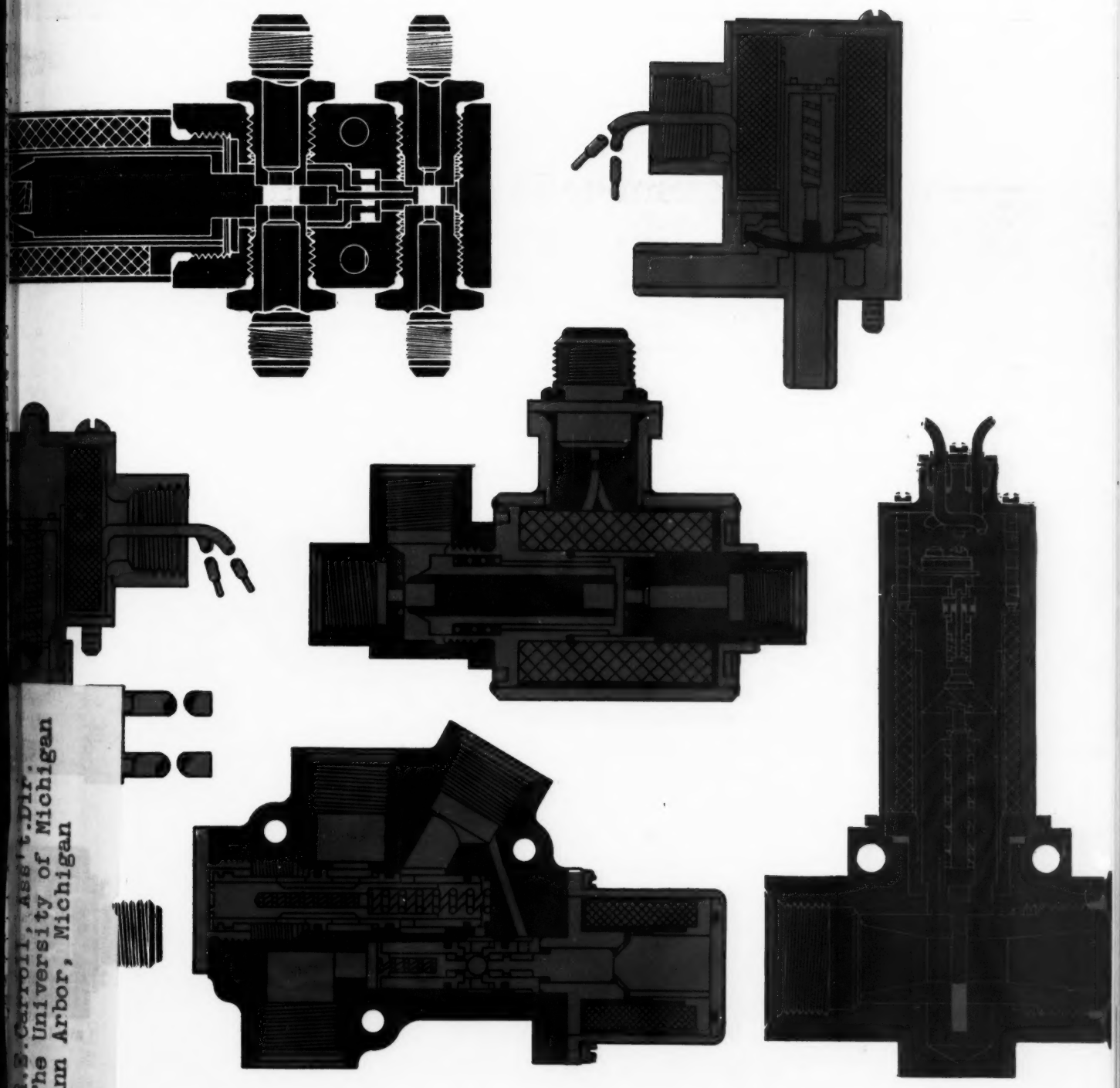
ELECTROMECHANICAL

components & systems | DESIGN

JANUARY 1959

solenoid valves



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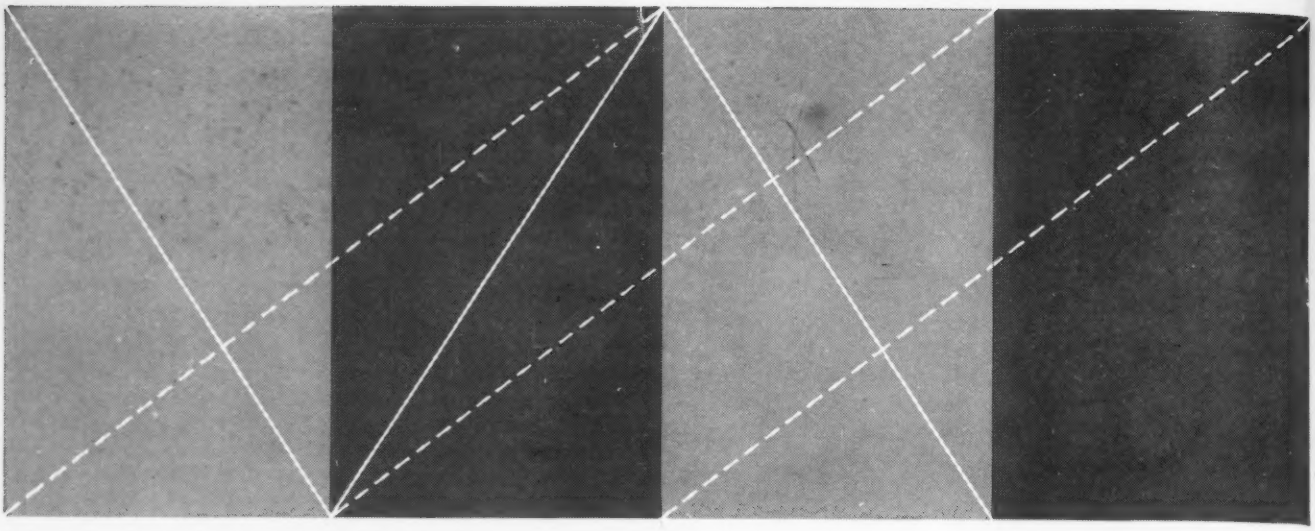

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CIRCLE 1 ON INQUIRY CARD

The Sourcebook of Design Ideas in Applied Electromechanics

VOL. 3 NO. 1

JANUARY 1959

ELECTROMECHANICAL components & systems DESIGN

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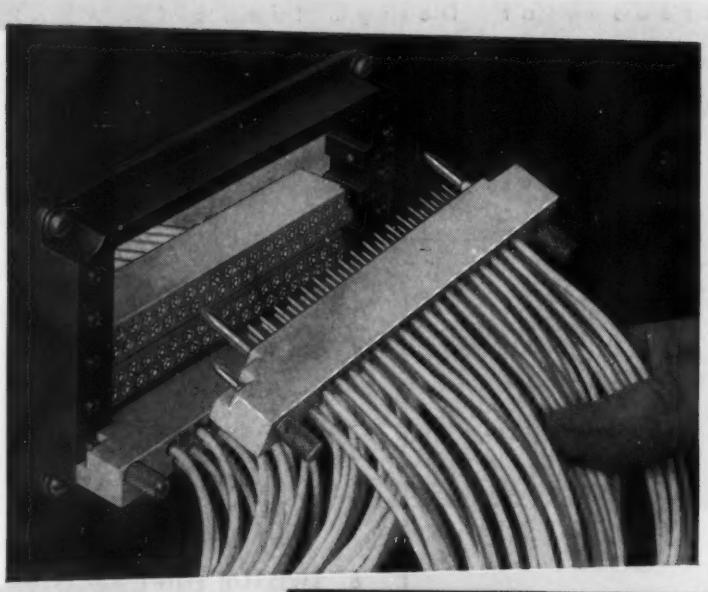

crimp-type

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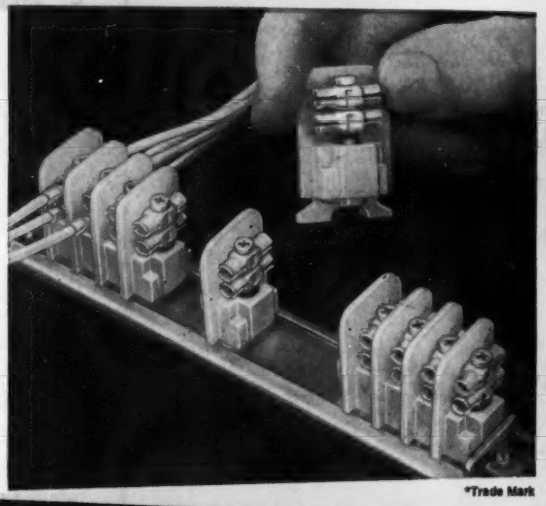

*Trade Mark

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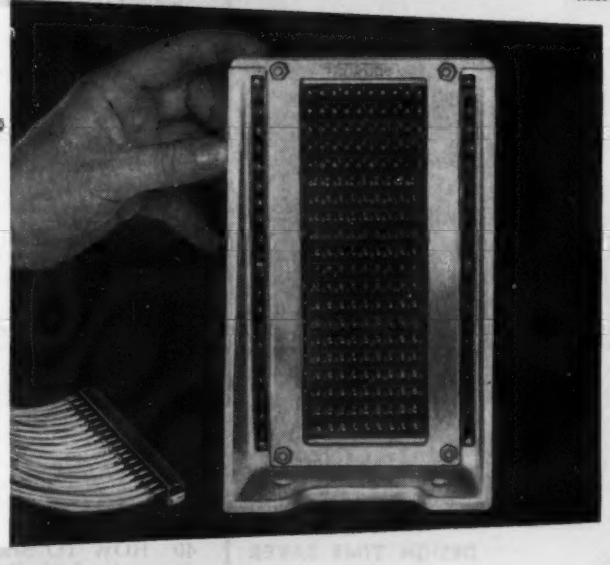

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EDITORIAL NOTES

Kudos and Brickbats

Kudos poured in from all directions—letters, telegrams and phone calls—as a result of our publishing Components Digest II: Precision Potentiometers (December 1958 issue). We were particularly proud and pleased that praise not only came from engineers who wanted and needed the kind of information we gave them on precision potentiometers but that they came from the engineers who design and develop precision pots as well as from engineers who select them for myriads of applications. Five of the largest manufacturers of precision pots wanted anywhere from 100 to 500 copies of the magazine to distribute to their sales engineers as one of the best compilations of precision potentiometer information that they have ever seen.

Unfortunately we had underestimated the demand for extra copies of this issue . . . by about 2500. So if you are one of our readers who requested a copy of our December issue, please accept our apologies; we're completely out. But here's a word of warning. Components Digest III, Electromagnetic and Potentiometer Transducers will be published in February. You can make sure of your copy in advance by filling out one of the inquiry cards in the book if you are not a regular subscriber. As a matter of fact if you are interested in the entire schedule for the Components Digest series for the remainder of 1959, you'll find it on page 3 of our December 1958 issue. Those of you who do not have the December 1958 issue can receive a copy of the schedule by circling no. 30 on the readers service card.

Chicken? Not Us!

"What's the matter—did you chicken out?" was what greeted me when I answered the phone on a person-to-person call from a job shop engineer in Syracuse, N.Y. This was only one of many calls and letters we had, all wondering what had happened to Part II of Herbert Spirer's column on "U-Drive-It Engineers"; Part I was published in November 1958. You will find Part II on page 34 of this issue. We had to postpone it because we received some excellent precision pot information that we felt had priority for inclusion in December. Next time we'll say Part II of anything we publish will be in a "future" issue or "will be published soon."

Creativity and You

Just a year ago (January-February 1958) we published "Emotional Blocks to Creativity" by Dr. A. H. Maslow, Professor of Psychology at Brandeis University. Reader response was overwhelming and we invited Dr. Maslow to be a regular staff columnist on this topic. We think that of all the articles on creativity, you may have read, you'll find Maslow's is unique.

Why? Read Part I of his "Creativity in Self-Actualizing People." You'll find it on page 36.

Robert B. Brotherston
Editor

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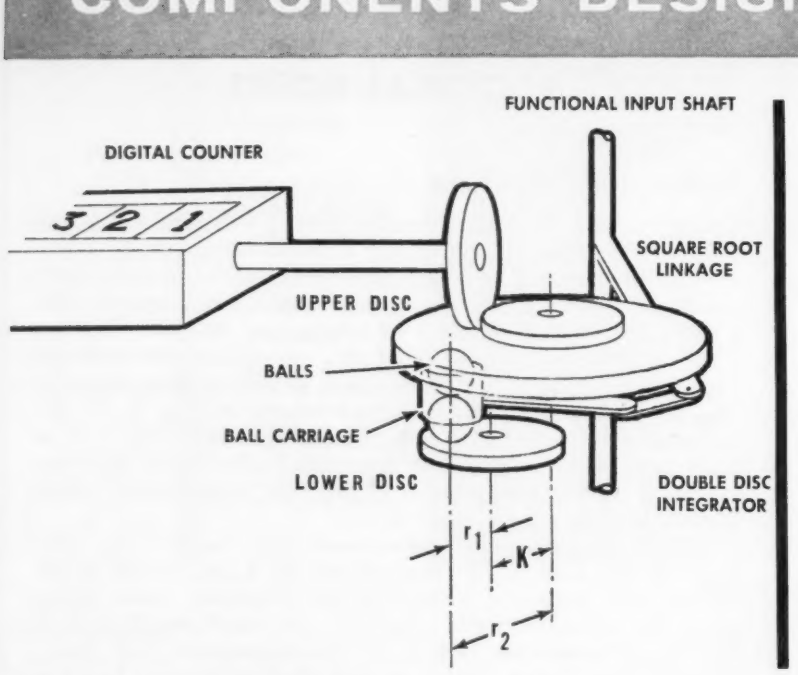


Fig 1—The square root linkage enters the value of the velocity head as radial displacement of the ball carriage from the center of the lower disc. Constant rate of rotation of the lower disc provides a time base for the integration.

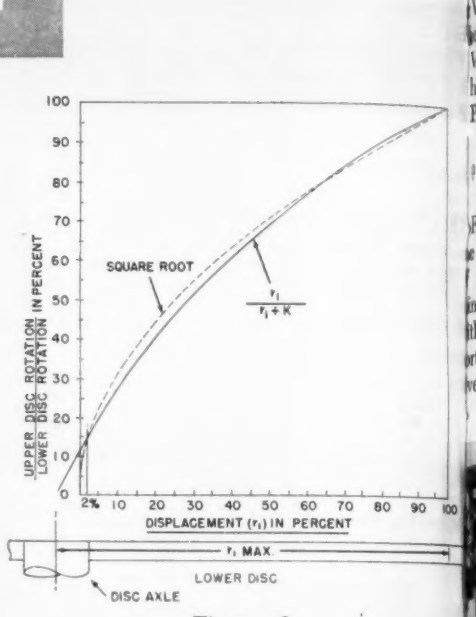


Figure 2

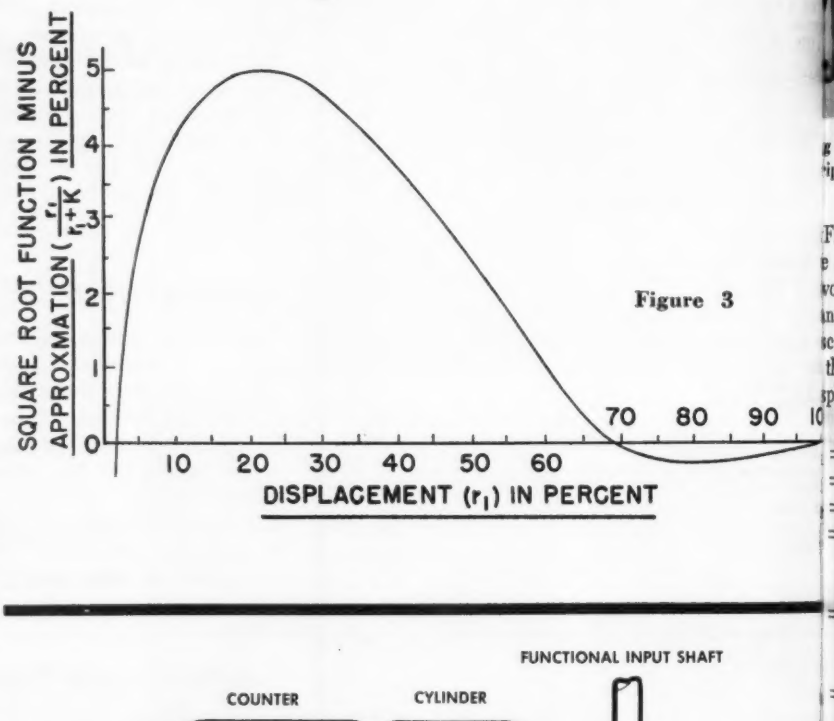


Figure 3

FLOW METER

Square Root Integrator Reads Total Flow

Flow calculations require square root functions to determine flow rates from pressure measurements. A new technique developed by Librascope, Incorporated, Burbank, California, combines the generation of the square root with the summing action of an all-mechanical integrator to provide direct readings of total flow. Designed to meet the needs of the flow metering industry for a simple, reliable and accurate means of continuously totaling flow, the square root integrator is now serving in chemical processing and fluid distribution systems in the form of a Model 26 Square Root Integrator for use in liquid systems. Two of the integrators are combined in a Model 90 Flow Computer to provide pressure-compensated totalization of gas flows.

In operation, the square root integrator accepts outputs from pressure sensing devices which are proportional to the velocity head of the flow, extracts the square root which is proportional to the flow rate and integrates this value with respect to time, giving an output proportional to the total flow.

Basic mathematics involved in the solution of the equation:

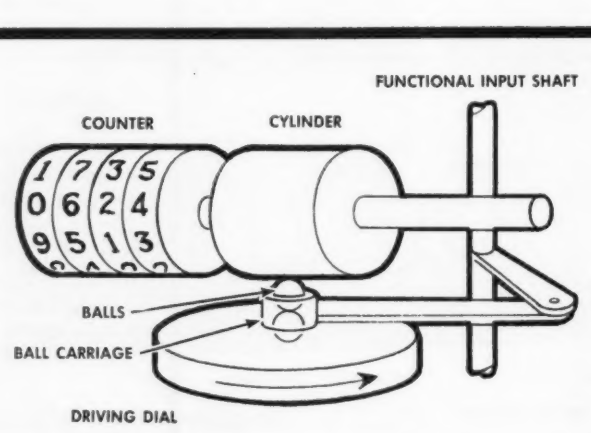
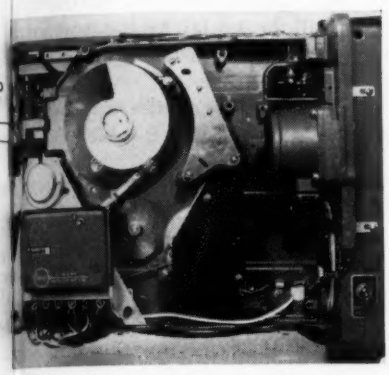


Fig 4—Mechanical integrating concept employed in the square root integrator is also available in Librascope's Model 25 Linear Integrator. This instrument provides linear integration of instrumentation output. Displacement of the ball carriage from the center of the disc is directly proportional to the input. Rate of rotation of the cylinder is then proportional to rate of rotation of the disc time radial displacement of the ball carr Total rotation of the cylinder a corded by the digital counter is portional to the time integral of input.

$V = (2gh)^{1/2}$
$V = (2gP/\rho)^{1/2}$

ere
V = velocity of the flow in ft/sec
h = dynamic velocity head in ft
P = pressure equivalent of the dynamic velocity head in lb/ft²
ρ = density in lbs/ft³

Flow velocity can be calculated from e above equation if the square root the velocity head can be deterined. Integration of the fluid velocity th respect to time gives a value proortional to the total fluid flow in a ven time period.



g 5—Linear integrator applied to ip chart recorder.

Figure 1 is a simplified diagram of e square root integrator mechanism. vo steel balls in the ball carriage nsmit rotation of lower disc to upper sc. Relationship between the rotation the two discs, a function of the radial splacement of the ball carriage, is:

$= r_1 \omega_1;\ V_2 = r_2 \omega_2$
= angular velocity of the lower disc
= angular velocity of the upper disc
= radial distance of the ball carriage from the center rotation of the lower disc
= radial distance of the ball carriage from the center rotation of the upper disc
$= V_2 =$ linear velocity of points 1 and 2 at point of contact of balls on lower and upper disc

lving for the rate of rotation of the per disc:

$\omega_2 = (r_1/r_2)\omega_1$

Formation of the square root of the put to the device is accomplished by anging the ball carriage and discs that the rate of rotation of the upper sc is equal to the constant rate of ation of the lower disc multiplied by factor that is proportional to the uare root of the input. Centers of e two discs are displaced horizontally that the radial displacement of the

of the o
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disc time
e ball car
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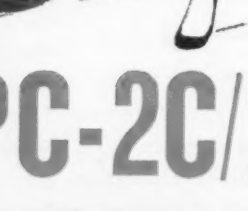

In addition to PC type relays (specifications below), Advance can also supply PG (general purpose) and PV (very heavy duty) power-type relays, with contact ratings varying from 15 amps to 30 amps.

SPECIFICATIONS

Coil resistance, DC: From 16 Ohms, at 6 volts, to 4,000 Ohms, at 110 volts.
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Contact arrangement: From SPST, NO or NC, up to 4PDT.
Nominal power required, DC: 2 to 3 watts.
Nominal power required, AC: 10 to 12 volt-amperes.
Contact rating: 15 amps resistive, 5 amps inductive at 115 volts AC or 26.5 DC.

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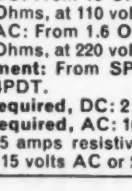
Data sheets are available on the PC series (power control), the PG series (general purpose power transfer), and the PV series (very heavy duty power transfer).



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ball carriage from the center of t
upper disc, r_2, can be expressed
the sum of the displacement of the b
carriage from the center of the low
disc, r_1, plus a constant distance,
which results in the following expr
sion for the rate of rotation of the u
per disc:

$$\omega_2 = (r_1/r_2)\ \omega_1 = [r_1/(r_1 + k)]\ \omega_1$$

When the distance k is set at 0.3
inches, the factor is found to appro
mate the square root of r_1. That is,
an input which results in the displa
ment of the ball carriage by an amou
r_1, the rate of rotation of the upp
disc will be equal to the square r
of r_1 times the constant rate of rotat
of the lower disc.

The accuracy of the approximat
can be seen in Fig. 2 which is a p
of the value $\frac{r_1}{r_1+k}$ versus the displa
ment, r_1. Superimposed on this plo
an exact square root function of
displacement, r_1. The two curves int
sect at a point which represent 2 p
cent of the full horizontal scale a
corresponds to the radius of the a
of the lower disc.

Maximum error between the t
curves is less than 5 percent over
entire operating range. A magni
plot of the error is shown in Fig. 3

Compensation for the disagreem
between the approximation to
square root function and the act
value of the function is provided
the linkages which form the in
mechanism. Careful design of th
compensating elements has redu
the difference so that the square r
integrator maintains linearity wi
0.25 percent of full scale with a
peatability of 0.05 percent of full sc

When the upper disc rotates a
rate proportional to the flow rate,
total rotation is proportional to
total flow. The value of the total f
is recorded continuously by the dig
counter geared to the upper disc.

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pound for O-rings and other mol
seals meets the requirements of sp
fication AMS 3335 and can be used
engines or weather resistance oils do
to −100F; for limited periods at t
peratures up to 500F; and in hi
aniline oils to 350F. Parker Seal
Div. of Parker-Hannifin Corp., Cle
land 12, Ohio or Culver City, Cal.

Circle No. 208 on Inquiry Card

EDDY CURRENT CLUTCH

Electromagnetic Coupling in Large Antenna Drive Control

The problem of medium power drives for closed loop systems operating at relatively constant speed is an old one. Most satisfactory solutions generally include use of Ward-Leonard or Amplidyne drives. G. B. Electronics Corp. of Valley Stream, New York has applied an eddy current clutch to the solution of this problem for a large antenna drive, with excellent results.

The eddy current clutch is a two-member device with the input driven by a conventional drive motor rotating at approximately constant speed. Coupling with the output is achieved by applying excitation generating drag torque in a metallic disc on the driven shaft. Naturally, the eddy clutch like all clutches is only efficient when operating at relatively low slips. Characteristic performance curves of the eddy current clutch are illustrated in Fig. 1. These curves indicate the essentially linear characteristic of the clutch for motor speeds at excess of 600 rpm over the range of field excitation. With an assumption of linearity, the La-Place transfer function block diagram for the complete drive loop is as shown in Fig. 2. The first block in the forward loop represents the time delay in the buildup of current in the eddy current coil. This time delay can be minimized by proper design in the input circuit. The second term represents the linear approximation to the characteristic of the clutch itself.

Use of the eddy-current clutch affords several advantages over other electric drive systems for comparable power requirements.

- Smooth transmission of power from very lowest speed to slew speeds.
- No commutators or slip rings, as there are on motor drives, so higher reliability and noise free operation are obtained.
- The drive motor continually turns at full speed. Thus, by using inertia of the motor, higher accelerations can be had with a smaller motor.
- The servo system is independent of the characteristics of the motor, and is dependent only on the clutch transfer function, which can be made very good.

G. B. Electronics Corp. designed this control for driving a 60-foot parabola antenna which was to be positioned to an accuracy of two min. of arc while tracking at 0.1 rpm in winds up to 60 mph. Tests on the system achieved much better performance.

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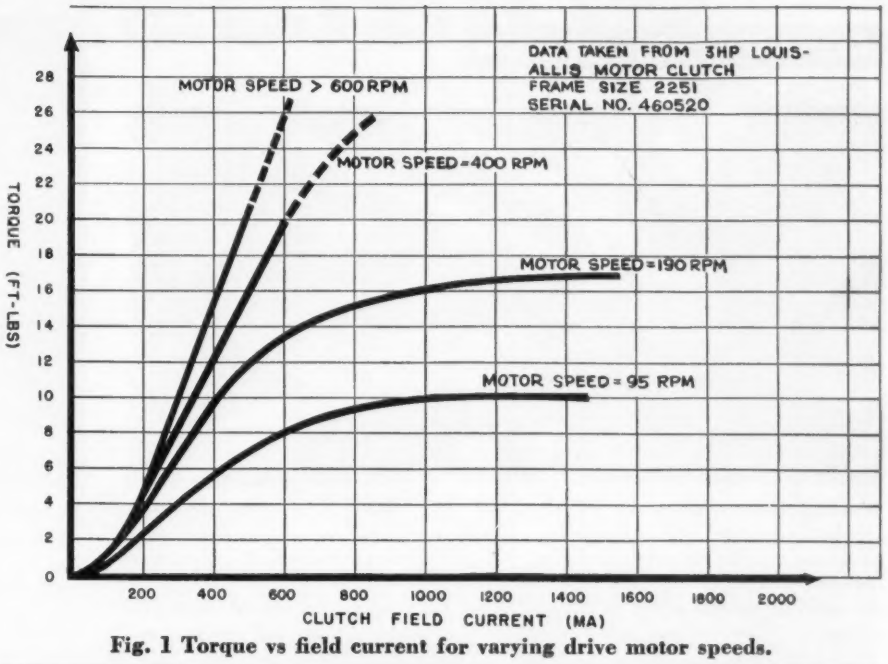


Fig. 1 Torque vs field current for varying drive motor speeds.

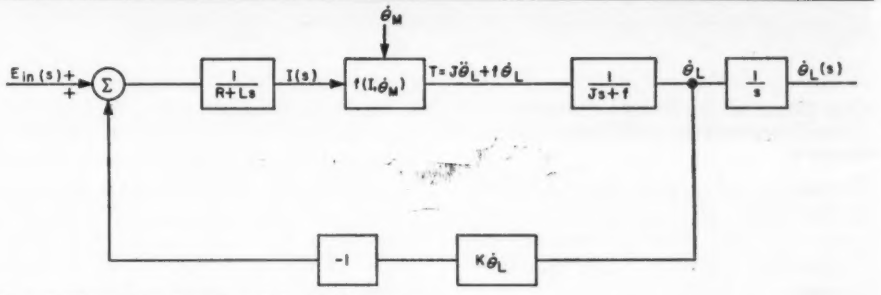
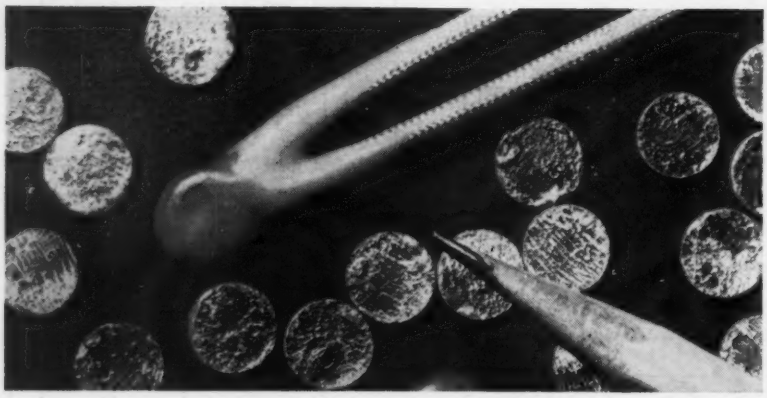


Fig. 2 Transfer function block diagram of G. B. Electronics Corp's. eddy-current clutch control system.

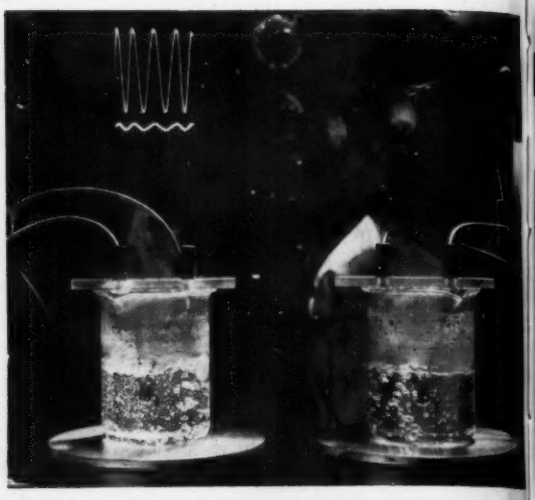
S—Laplace Operator
R—Resistance of clutch field
L—Inductance of clutch field
I(s) Current through clutch field
T—Torque developed
J—Inertia of moving parts (loan and rotating disk)
f—Friction and windage
θ_M—Velocity of driving motor
θ_L—Acceleration of load
$\dot{\theta}_L$—Velocity of load
$K\dot{\theta}_L$—Proportionality constant relating load speed to feed back voltage

	EDDY CURRENT CLUTCH	D.C. MOTOR
TIME CONSTANT	0.075 to 0.15 sec.	The better permanent magnet d-c servo motors have a time constant of 0.13 sec.
WEIGHT	The e-c clutch and motor combination are quite heavy and bulky to mount.	If the motor alone is taken, its weight is comparatively light. However, if the associated M-G equipment is taken into consideration it is much heavier than the clutch.
COST	Relatively cheap	Much more expensive than the e-c clutch.
RELIABILITY	Extremely reliable	Relatively unreliable. Brushes and rings wear out and require continual replacement.
R. F. NOISE	Generates no R. F. noise	Because of the brushes, noise is generated and may become a problem at the higher frequencies—especially when the signal level is low.
DRIFT	E-C clutches lend themselves to control by a-c amplifier, thus eliminating the drift problem.	High drift because of the required d-c amplifier.

TABLE I. Comparison of eddy current clutch control with conventional servo.



Westinghouse switching thermistors are solid-state, temperature-sensitive devices whose resistance increases abruptly when their temperature reaches a critical value. Silvery discs in the photograph are ceramic wafers to which a metallic surface has been applied. Complete thermistors result when discs are fitted with leads, insulated, and encapsulated for proper mechanical, electrical, and thermal properties.



Switching thermistor at left displays its normal resistance at temperature of 100 degrees C; Switching thermistor at right, in boiling solution of ammonium chloride, displays resistance roughly twenty times higher at temperature of about 112 degrees C.

POSITIVE TEMPERATURE COEFFICIENT THERMISTORS

New Thermal Switches Prevent Over-Temperature of Hermetic Motors

Thermistors of a new type developed by the Materials Engineering Laboratories of the Westinghouse Electric Corporation constitute tiny contactless thermal switches.

Their resistance increases substantially when their temperature rises to a specified point and returns to nominal value when they are cooled below that point or level. Thus, when their temperature reaches the critical point, they become high resistance circuit elements and, with no moving parts, perform the function of a switch by effectively opening the circuit. When their temperature falls below the critical point, their resistance returns to a quite low value, so that they act as a conductor to close the switch.

The new devices are called Positive Temperature Coefficient Thermistors to indicate that their resistance increases with temperature in contrast with conventional thermistors whose temperature coefficient of resistance is negative. Other contrasts are these: Within their respective operating ranges, the sensitivity of the new thermistors is many times that of conventional thermistors and their temperature ranges in which switching occurs are very sharply defined and are controllable.

By varying the composition of the switching thermistor during manufacture, it is possible to precontrol both its residual resistance and the temperature level at which switching occurs. For example, thermistors for motor over-temperature protection will switch at specific temperatures between 100 and 125 degrees C and will function in control circuits requiring a 17:1 ratio of maximum to residual resistance.

Positive Temperature Coefficient Thermistors now being produced are small ceramic discs, roughly the size of aspirin tablets, that are surfaced on opposite faces with a metallic coating. Before use they are fitted with leads and encapsulated in an epoxy resin having proper thermal, electrical, and mechanical characteristics.

Initial quantities of these new switching thermistors are going to the Motor Department in Buffalo, New York, where Westinghouse motor engineers have developed a new system for protection of motors against over-temperature conditions. Termed Guardistor motor protection, the system will be applicable to totally enclosed motors such as those used in hermetically sealed units for air conditioning and refrigeration units. In this system thermistors installed directly in the motor windings will operate a small external relay which de-energizes the motor or gives a signal when overheating occurs. Westinghouse expects to market hermetic motors with the new protective system shortly.

Circle 75 on Inquiry Card.

"TWISTOR" SHIFT REGISTER

Single Magnetic Wire Stores Pulses When Subjected to Magnetizing Field.

A reversible, diodeless shift register using a single magnetic wire as the memory element promises to be cheaper to build than conventional shift registers.

Shift registers, employed in most electronic computers and in many other applications, are essentially temporary storage devices that perform somewhat the same function as delay lines, except that the stored pulses can be shifted along at will.

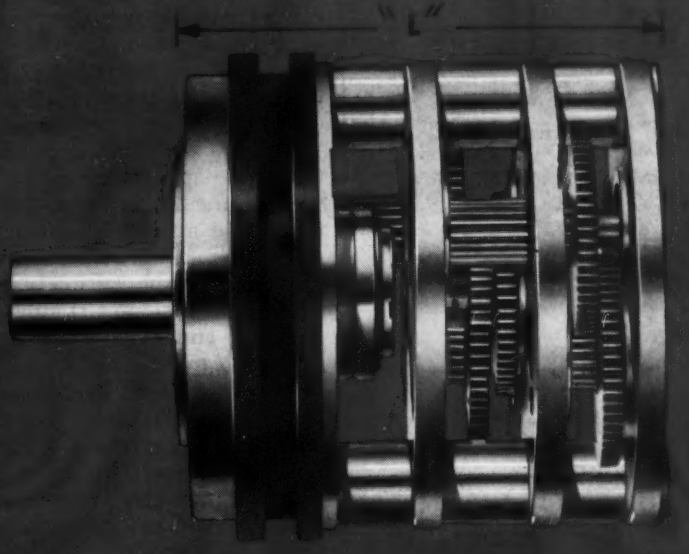
This shift register under development at Bell Laboratories takes advantage of the "twistor" technique recently developed at the same laboratories. A wire of magnetic material when twisted can be magnetized most easily in a spiral direction and can store pulses when subjected to a suitable magnetizing field. Amount of twist applied serves to regulate magnetic interactions between magnetized zones. These magnetized zones can be slid along the wire under control of externally applied multi-phase advance pulses.

In the experimental shift register, information bits are written in and slid along by means of tiny 8-turn solenoids, each 0.075 inch long and spaced 0.075 inch apart. These coils are wound on a ceramic tube and the magnetic wire (0.002 inch diameter permalloy is stretched through the center of the tube.

Simultaneous pulsing of three adjacent coils is necessary to insert a magnetized zone into the register. Two coils must be pulsed to slide this zone

EDISON PRECISION GEAR HEADS

- Sizes 8 through 18 available in any ratio within 1%.
- Mount directly on all Edison and Bureau of Ordnance Motors without adapters.
- Adapters available to mount on any motor.



CHARACTERISTICS	STANDARD EDISON GEAR HEADS									
Size	8		10		11		15		18	
Part Number										
Pinion Data: Number of Teeth	12		13		13		15		15	
Diametral Pitch	120°		120°		120°		96°		96°	
Pressure Angle	20°		20°		20°		20°		20°	
Pitch Diameter	.1050" +.0 −.0005		.1083" +.0 −.0005		.1083" +.0 −.0005		.1562" +.0 −.0005		.1562" +.0 −.0005	
Gear Ratio to Length "L"	Ratio	"L"	Ratio		"L"	Ratio	Ratio	"L"	Ratio	
	17	0.750	31		0.781	36	40	0.812	60	
	42	0.812	93		0.954	108	140	1.000	240	
	104	1.008	280		1.054	324	490	1.100	960	
	253	1.070	840		1.116	972	1715	1.162	3840	
	615	1.204	2521		1.266	2916	6000	1.328	15,360	
	1494	1.347	7565		1.409	8748	21,000	1.487	61,440	
	3629	1.421	22,696		1.500	26,244	73,500	1.600	245,760	
Moment of Inertia GM CM^2	.01		.018		.02		.05		.08	
Maximum Running Torque in. oz.	15		15		20		25		25	
Maximum Stall Torque in. oz.	35		35		40		50		50	
Breakdown Torque in. oz.	.01		.01		.012		.015		.018	
Backlash maximum	30′		30′		30′		30′		30′	

Gear Tolerances: Precision Class 2 AGMA 236.02. *Bearings:* Stainless Steel ABEC Class 5 or better. *Shaft Radial Play:* .002"/inch length max. with 4 ounce gage load. *Shaft End Play:* .002" max. with 1 pound gage load. Friction Slip Clutch available on request. Designed to meet applicable paragraphs of MIL-E-5272.

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INSTRUMENT DIVISION
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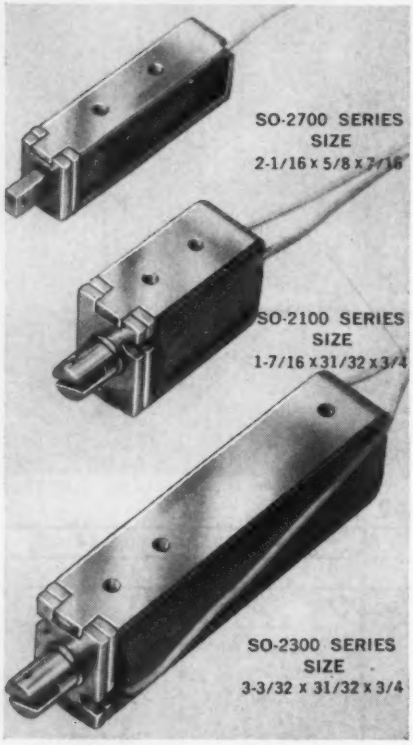
CIRCLE 8 ON INQUIRY CARD

POLLAK

STANDARD D-C SOLENOIDS



- MINIATURE, LIGHT WEIGHT, COMPACT
- MAXIMUM POWER FOR MINIATURE SIZE
- VARIETY OF MOUNTINGS, COILS, WIRE SIZES
- PLUNGERS DESIGNED FOR PUSH OR PULL

High magnetic efficiency results in an unusual power-to-size ratio making these solenoids ideal where miniaturization is important. General applications include: automatic process control, automatic machinery, communications, automation and computation.

As a design aid for applications involving linear solenoids write for new Brochure which includes detailed procedure and all pertinent information necessary for determining the proper solenoid. Included are: graphs of force-stroke, temperature rise-power, temperature rise-time and tables of standard coil resistances.

Pollak also offers a wide variety of special and standard relays, solenoids and switches.

Since 1909
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CIRCLE 21 ON INQUIRY CARD

along the wire. For example, if a "bit" is stored by pulsing coils 1, 2 and 3, it can be moved along one space by properly pulsing coils 1 and 4. The pulse current required for the advance operation is about 140 ma. To clear the wire after a bit has been advanced, the erase coil is pulsed with about 240 ma.

To read out the signal at the end of the register, a pulse of about 170 ma is passed through three special "readout" coils. If a "bit" is present, a voltage pulse appears across the magnetic wire. In the absence of a "bit", no voltage pulse appears.

Tests on a 5-advance register have demonstrated the feasibility of this device. It is capable of storing three bits per inch, and calculations have shown that the capacity can be increased to ten bits per inch. Bi-directional operation is easily secured. No diodes are required, thus allowing a reduction in the drive power. The upper frequency limit has not been established, but a several hundred kilocycle bit rate should be possible.

5-advance twistor shift register developed at Bell Telephone Laboratories. The tiny solenoids are wound on a ceramic tube and the magnetic wire is stretched inside the tube.

DIGITAL ENCODER WITH MAGNETIC READOUT

Barium Ferrite Disc Radially Spot Magnetized Eliminates Contacts.

A shaft-position digital encoder employing a unique principle of magnetic readout provides exceptionally long life because it has no mechanical or optical contact and uses only passive circuitry.

Developed by the Applied Science Corp. of Princeton, the encoder also offers these important advantages:

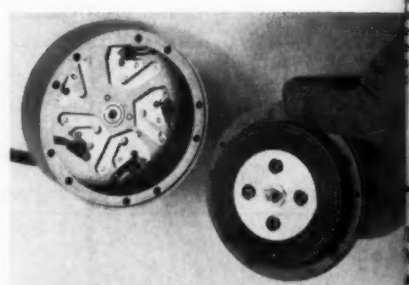
Performance is unaffected by heat or cold, humidity, dirt and dust and other adverse conditions often encountered in industrial applications.

Accuracy and life are unaffected by number readouts, rate of readout or whether readout is made in a moving or stationary system.

The magnetic readout technique involves a shaft-mounted barium ferrite disc radially spot magnetized in discrete code spots arranged in concentric tracks around the wheel. The code spots are invisible and never wear out.

Mounted directly above the path of each track close to but not touching the disc is a micro-miniature toroid. As the disc turns under the influence of a shaft input and a magnetic spot passes beneath a toroid, the toroid suddenly saturates in the magnetic field and its impedance drops to zero.

Readout is accomplished by interrogating the toroids with a constant current pulse. A voltage pulse appears across those toroids not in the magnetic field, while no pulse appear across those toroids saturated in th magnetic field.



ASCOP EDP-3 Digital Encoder use unique technique of magnetic readou

In this simple fashion, a binary or 0 is generated on demand. Angula position of the disc is determined b the output pulse code within ½ degre resolution of the disc whether it is a rest or rotating as fast as 10,000 rpm Rate of interrogation can be as high a 5 million interrogate pulses per second

Input to the encoder can be an shaft position. Binary code output o the encoder can be fed directly t amplifier and control circuitry. Som typical examples of control circuitry would be tape punches, printers an similar data logging equipment, o shift-register/computer combinations.

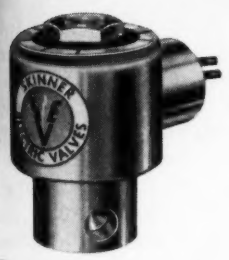
The encoder is 3-¾ inches in diam eter and 1.39 inches long. Its torqu (breakaway) is 0.2 inch ounce.

Circle 69 on Inquiry Card.

CIRCLE 5 ON INQUIRY CARD

SKINNER SOLENOID VALVES

THE CREST OF QUALITY



Two-way C Series

A high quality, 2-way, miniature cut-off valve offering top performance at lowest price. Small, lightweight (only 12 oz.) yet designed to operate for millions of cycles in automotive fuel systems, oil burners, vending machines, dental equipment, air horns, welding equipment, humidifiers, automated systems, etc. Available normally closed only.

Two-way L Series

A newly designed high-flow industrial valve for use with all common media such as water, oil, air, etc. Light and compact, it mounts directly to the line. Forged naval brass body, stainless steel parts and fully supported diaphragm assures long life and troublefree operation. Available normally open, normally closed and explosionproof.

Two-way R Series

A 2-way, pilot operated piston valve for use with all common media including air, inert gases, water and oil at standard and high pressures up to 1250 psi. Light and compact, it can be mounted directly to the line in any position and has a life expectancy of millions of cycles on most applications. Available normally closed, normally open and explosionproof.

Two- and Three-way V10 Series

Extremely compact, direct-acting slide type, high pressure hydraulic valve up to 1000 psi. Balanced pressure design provides maximum power. Same valve can serve as either a 2- or 3-way normally open, normally closed or 3-way directional control in machine tools, door openers, hydraulic cylinders, construction equipment, pilot for larger valve, etc.

Two- and Three-way V5 Series

Available in 2- or 3-way and explosionproof construction, this is the most popular and versatile stainless steel valve series. Over 100,000 variations available. Unlimited applications include machine tools, instrumentation, automation, air and hydraulic cylinders, oil burners, LPG equipment, dispensing machines, automotive, aircraft, dehumidifiers, laundry equipment, etc.

Three-way A Series

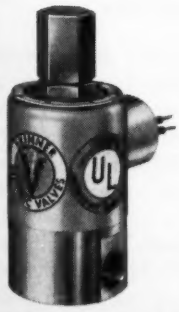
A new valve line designed for economical and efficient operation of medium size cylinders, this valve bridges the gap between the famous V5 line, used with small cylinders, and the reliable M3 line for large cylinders. It also provides faster operation of smaller cylinders where increased cycling speed is called for. It is designed for use with such media as air, oil and inert gases and can be used for vacuums down to 5 microns. Available normally open, normally closed, directional control and multi-directional.

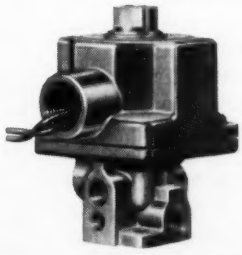
Three-Way M Series

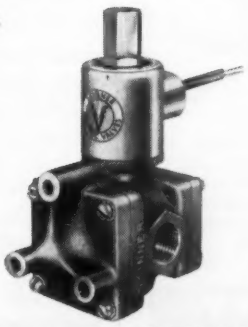
A 3-way valve for reliable high-flow industrial service under rugged conditions of use. Free-flow design provides large capacity with minimum sensitivity to media impurities in air vises, process equipment, presses, water treatment, air and hydraulic cylinders, machine tools, automotive equipment, etc. Available normally open, normally closed, directional control and explosionproof.

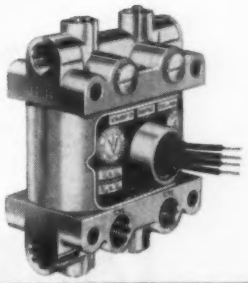
Four-way V9 Series

A compact, direct-acting, flexible all-purpose 4-way valve. Optional porting arrangements and speed control combinations provide over 350 basic variations for accurate, dependable control of single and double-acting cylinders, larger pilot-operated valves, etc. Available normally closed — normally closed, normally open — normally open, normally closed — normally open.









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SHIFT REGISTERS

LOWEST POWER/BIT
. . . up to 25 stages driven by a 50 mw transistor

LOWEST COST/BIT
. . . $4.90 for 25 kc unit

HIGHEST ONE/ZERO RATIO
. . . up to 30:1 minimum

- Available for up to 65°C or up to 125°C operation
- Shift rates up to 3,000,000 bits/sec.

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CIRCLE 27 ON INQUIRY CARD

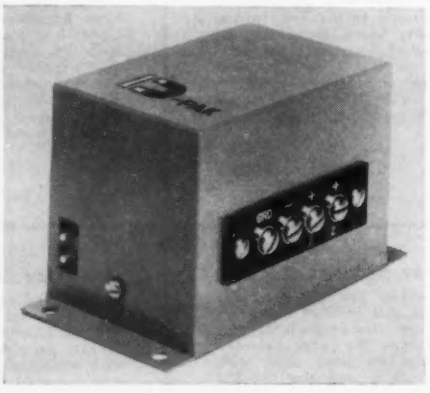
SYSTEMS DESIGN

ZENER CONSTANT CURRENT SOURCE

Solid State Circuiting Replaces Standard Cells and Standardizing Mechanisms in Potentiometric Instruments

Industrial potentiometric instruments for recording process information have been designed around the dry cell battery for supply of measuring current and the standard cell for control of accuracy. Although this technique has been generally accepted, its drawbacks are many: battery life is limited and failure often unpredictable; assumptions regarding battery behavior are required in specifying accuracy. In addition, with the standard cell, interruption of measurement is necessary to compare and adjust the battery voltage to that of the standard cell.

To replace the conventional system, a source of sufficient power with the accuracy of standard cell was needed. It had to be independent of changes in line voltage and ambient conditions, and have indefinite life.



D-Pak Constant Current Source

Daystrom-Weston Industrial Division of Daystrom, Inc., Newark, N.J., has developed such a source using solid state circuitry instead of conventional mechanical parts or vacuum tubes. The company claims the new circuit, called D-Pak, eliminates many conventional components, provides full time accuracy, eliminates frequent standardization and reduces maintenance. Its accuracy is said to be 5 times greater than the 1/4 percent accuracy of the potentiometric instruments themselves.

ALL SOLID STATE CIRCUITRY

D-Pak uses refinements in semi-conductor manufacture that have brought under control the avalanche (or Zener) effect for voltage regulation. When an inverse voltage is applied to a solid state diode, the effect results in a fixed terminal voltage across the diode. Research into the characteristics of diodes exhibiting the Zener effect, combined with careful choice of precise and stable components, has resulted in a device which exceeds the accuracy of the standard cell.

The D-Pak eliminates batteries by drawing its power from the same power line that supplies the rest of the potentiometer. This alternating voltage is stepped down through a transformer, rectified, filtered, and passed through two stages of Zener diode regulation. Optimum choice of regulator circuit has resulted in a very small change in output with a change in supply voltage. Compensation for the known temperature coefficient of the Zener diode controls the effect of temperature change. Ambient temperature changes effect the output less than 1/500 per cent per degree F.

Circle No. 51 on Inquiry Card

Transistor-Magnetic Servo Amplifier

A miniature high-gain transistor-magnetic servo amplifier is ideally suited for high-speed, high shock and vibration aircraft and missile applications. Rated for operation at temperatures ranging between −55C and +100C, the compact amplifier features silicon transistors in its servo amplifier section, together with an integral fast response magnetic amplifier. A plug-in type component, this amplifier is extremely small and light-weight and has a power output of 3.5 watts with either a 0 or phase shift depending on the tuning capacitor selected. Power input is 115, 400 CPS, 210 ma and 27 VDC, 30 m. Kearfott Co. Inc., Clifton, N.J.

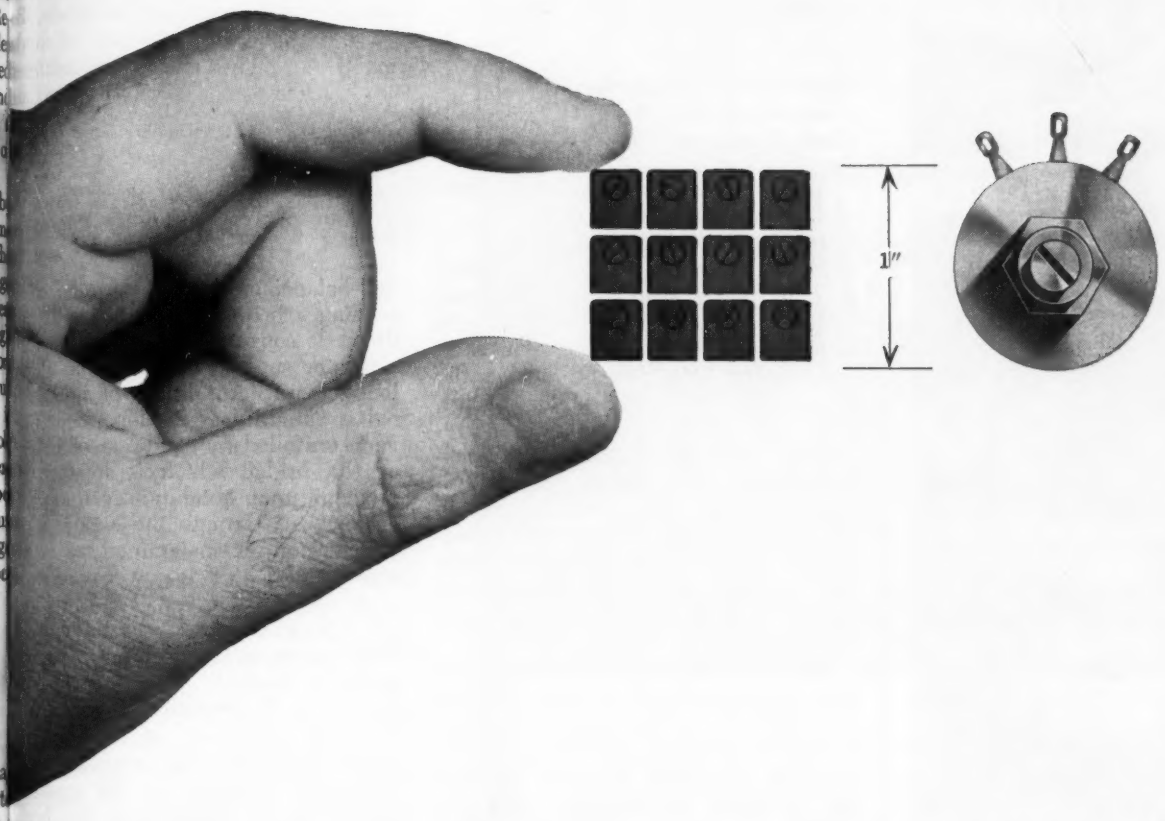
Circle No. 120 on Inquiry Card

WORTH FILING

Switching Reactors

Switching reactors for one-step, low cost static control perform all logic functions and are applicable to switching and sequencing installations. Sixteen-page catalogue describes three types of units: one operates from standard line 120 voltages, the other delivers standard load voltages. Catalogue contains tables of electrical characteristics and typical application circuits as well as complete descriptions of the units, their application and physical dimensions.

Source: Control, Division of Magnetics, Inc., Butler, Pennsylvania
For Your Copy: Circle No. 220 on Inquiry Card



FIT 12 OF THESE RECTANGULAR POTENTIOMETERS IN A PANEL AREA OF 1 SQUARE INCH!

You can pack 12 Bourns TRIMPOT® potentiometers in the 1-square-inch area occupied by the average single-turn rotary.

Fit the TRIMPOT into corners—between components—flat against a chassis or printed circuit board. Mount them individually or in stacked assemblies. Any way you use them—Bourns potentiometers save space!

You can adjust Bourns potentiometers more accurately, too. The 25-turn screw-actuated mechanism gives you 9000° of rotation instead of 270°. Circuit balancing and adjusting is easier, faster. Repeatability is assured every time. Furthermore, adjustments are self-locking—shock, vibration and acceleration have no effect!

Write for new Model Summary Brochure

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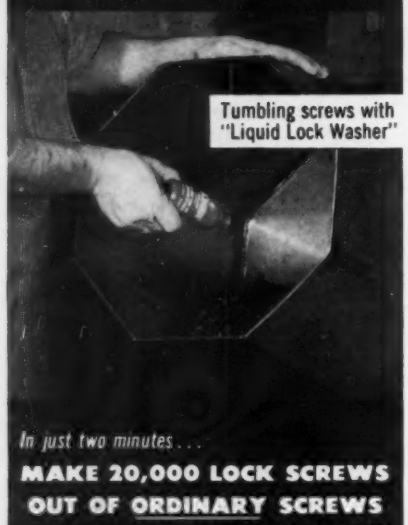
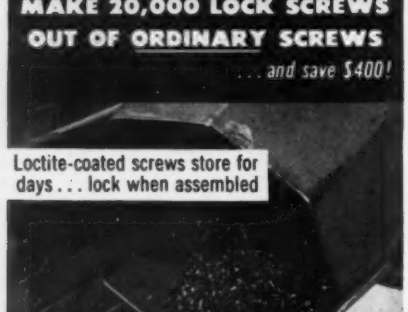
NEW LIQUID LOCKS SCREWS



In just two minutes...
MAKE 20,000 LOCK SCREWS OUT OF ORDINARY SCREWS
...and save $400!



Loctite is the liquid lock that makes any threaded part self-locking. Loctite converts automatically to a tough, heat and oil-resistant plastic seal when confined between engaged threads. Locking action develops over the entire contact area, providing unequalled resistance to vibration. No heat... no mixing... not sticky.

Whether you use 20 or 20,000, you can get savings of up to 70% using Loctite and ordinary fasteners to replace more costly mechanical lock fasteners. For product reliability at lowered production cost, send for complete information on Loctite.

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CIRCLE 20 ON INQUIRY CARD

LUMISTORS

Electroluminors Combined with Photoconductors Amplify Electric Signals

A new category of active components combining a phosphor having a voltage controlled light emission and a solid state photoconductor is capable of high power gain of an electronic signal. The signal controls the light emission of the phosphor which in turn controls the current flow of the photoconductor circuit. This device, called the lumistor, was recently reported by Charles F. Spitzer of Lockheed Aircraft Corporation, Missile Systems Division, Sunnyvale, Cal., in Lockheed Report LMSD-5187. Secondary functions of the unit include light intensification, visual indication, optical triggering, and spectrum conversion.

Many electro luminescent phosphors have been developed to date covering essentially the entire optical spectrum. A typical material (emitting in the green to blue-green spectrum) is copper activated zinc-sulphide. Unfortunately, the most efficient electroluminescent phosphors available to date respond to alternating voltage only, preventing practical application of signals. Cadmium sulphide photoconductive elements have highest sensitivity and slow response; lead sulphide is considerably faster with lower sensitivity.

Fig. 1 shows an electroluminor (emitting light with applied electrical signal), a photoconductor, and a load resistor R_L, arranged to function as an amplifier. A power gain of 48 db was measured for R_L equal to 0.4 megohms, with a zinc sulphide electroluminor and a cadmium sulphide photoconductor. Triggering may be developed by simple circuit modifications.

Advantages of lumistors in common with many other semiconducting devices lie in their low cost, small dimensions, and ease of storage and use.

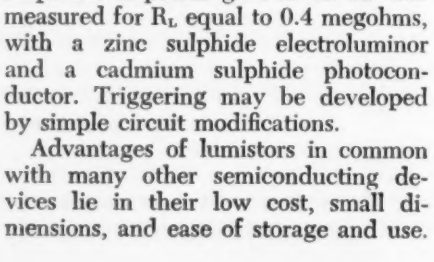

Fig. 1. Generalized Lumistor Circuit. Voltage sources may both be a-c or d-c depending on the phosphor chosen. EL=Electroluminor, PC=photoconductor.

Present performance limitations relate to photoconductor frequency response. Improvements permitting operation up to 5000 cycles per second appear reasonable. Lumistors are suggested as servo amplifiers, slow speed logic elements and relays, and in control circuit applications.

Circle 76 on Inquiry Card.

Transistorized Precision Power Bridge

Self-balancing device permits direct reading of RF power in watts and dbm. It consists basically of an audio oscillator and a bridge in a closed loop circuit. Amplitude of audio signal is variable and is dependent upon and controlled by condition of balance of the bridge which is in turn dependent upon total power in a thermistor that, through the action of the closed loop, is maintained at a constant value P_T. This power consists of

$$P_{audio} \pm P_{RF} + P_{DC}$$

(P_{DC} is a constant, caused by DC bias current in thermistor.) When RF power is applied,

P_{RF} equals zero

P_{audio} is therefore at a maximum value consistent with maintaining the bridge in balance. As RF power is applied to the thermistor, the bridge is unbalanced and the unbalance voltage is impressed across the input of the audio oscillator. P_{audio} is there by decreased until cumulative power in the thermistor is restored again to its constant value, P_T. At this point the bridge is balanced and no further change occurs in the audio signal. Output of the audio oscillator, which is then a function of the RF power applied to the thermistor, is displayed on a meter suitably calibrated in watts and dbm. The instrument is light in weight, battery operated and portable. Airborne Instrument Laboratory, Div. of Cutler-Hammer, Inc. Mineola, New York.

Circle No. 195 on Inquiry Card

WORTH FILING

GE Transmitting Tubes

8-page bulletin provides a comprehensive guide to all available G. E. electronic tubes for transmitting and allied applications. Publication lists lighthouse and planar types, magnetron, television camera tubes, Klystrons, triodes, tetrodes, diodes, reference cavities and gas discharge devices. Data include frequency, plate power output, ratings and operating conditions.

Source: General Electric Co.
Schenectady 5, N.Y.

For your copy: Circle No. 212 on Inquiry Card

FUSION SEALED GLASS CAPACITORS

Corning Glass Works has been making glass capacitors since World War II when their research scientists developed a method of forming flexible glass ribbon only a thousandth of an inch thick. Glass ribbon substituted for hard-to-obtain natural mica made possible a simple capacitor design with precise electrical characteristics and stability at temperatures up to 570 degrees F.

To meet military demands for electronic components with highest possible reliability in adverse environments, Corning has developed a new fusion-sealed glass capacitor, identified CYF. They use a specially developed, copper-clad lead to obtain a true glass-to-metal seal where the lead joins the capacitor body. The seal anchors the lead firmly, providing pull strength well above maximum requirements of MIL-C-11272A, and makes the capacitor impervious to moisture. The new leads also provide improved solderability and resistance to high frequency vibration.

In continuing tests at time of reporting sample capacitors had withstood more than 200 hours in a boiling, saline solution without deterioration. In high humidity atmosphere they show no significant change in capacitance or dielectric loss after more than 1000 hours.

Size 10 CYF capacitors, which have capacitance range to 240 mmfd and d-c working voltage up to 500 at 125 degrees C, are currently available in limited quantities. Eight units would fit on a postage stamp.

Announcement of these new fusion-sealed glass capacitors coincided with Corning's official opening of their new 142,000 square foot plant to house their Electronics Components Department in Bradford, Pa. where glass capacitors, glass resistors and many other electronic components are being produced.

Circle No. 78 on Inquiry Card

Precision Components . . . another Kearfott capability.

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Kearfott components for missile and aircraft systems can provide optimum performance at temperatures as high as 200°C. Moreover, this peak performance is unaffected by 2000-cps vibration and 50-G shock. Kearfott's compact, light-weight and corrosion-resistant components provide this consistent record of accuracy:

Synchros: Sizes 8 through 25. Errors as low as 20 seconds from E. Z.

Motor-generators: Sizes 8 through 18. Linearity of 0.01%.

Servomotors: Sizes 8 through 25. Wound for transistorized amplifiers.

Kearfott research is continually developing even more accurate and more durable components . . . preparing for the needs of tomorrow. For details, write today or contact your nearest Kearfott sales office.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

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SOUTHWEST

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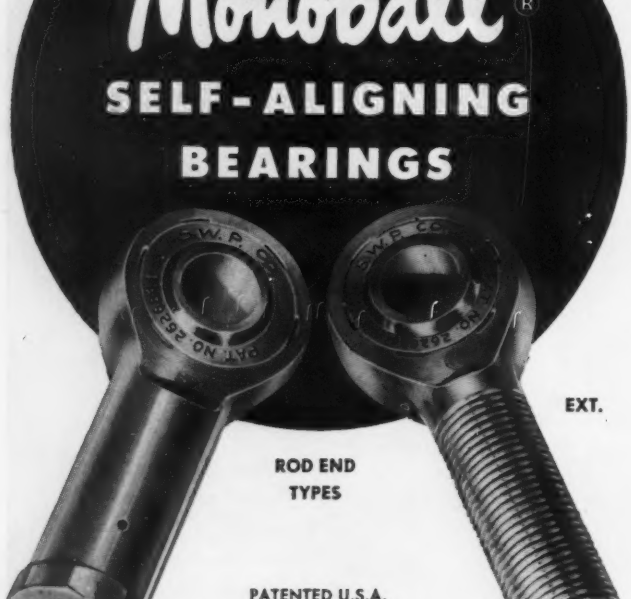

EXT.

ROD END TYPES

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1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. EMD-59

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CIRCLE 16 ON INQUIRY CARD

COMPONENTS

Tube Cap Connectors

Tube cap connector series combines outstanding thermo, electrical and mechanical characteristics of silicone molding compounds with special connector techniques. Designed for applications where the critical requirements are high voltage, high temperature and high altitude, the connectors are particularly suited for special airborn applications. Two types of silicone insulation are available: The first, glass-filled silicone for highest temperature applications, gives reliable service from −65F to +750F and withstands up to +1000F for short durations. Designed to meet MIL-M-14E, has high impact strength. The second, silicone rubber for high flexibility and resiliency, allows the configuration of the tube cap connectors to vary for special applications. Unique skirt shapes hug the outline of the tube bulb, providing a suction-like grip to seal out dust and moisture and eliminate chances for high-voltage flash-over. Available for high-voltage applications; temperature from −70F to +500F; extraordinary resistance to fatigue. Both types have outstanding dielectric characteristics and high resistance to ozone, moisture, or corrosive atmosphere and will not support fungus. Alden Products Co., Brockton, Mass.

Circle No. 225 on Inquiry Card

High Temperature Squaretrim "Pot"

One-half-inch precision Squaretrim potentiometers are now available for high temperature applications.

First of a new series of high temperature precision units, the new unit is available in resistance values from 10Ω to 50K ± 5%. Operating temperatures of this miniature 1.5-watt potentiometer range from -55 degrees to +200C. One watt is dissipated at +95C. The unit meets or exceeds MIL-STD-202 Method 202 shock and vibration, and NAS 710 noise specifications. Daystrom Pacific, L. A., Cal.

Circle No. 217 on Inquiry Card

Solenoid Design Provides Ultra-Rapid Response

High-speed solenoid which completes its stroke in less than 20 milliseconds operates with a 24-pound load. The start of the 0.020 inch stroke occurs at a maximum of 14 milliseconds and completes its travel in less than 20 milliseconds from circuit closing. Specified for operation in an ambient temperature range of from −65 to +160F with voltage rating of 24 volts DC at 78 F coil resistance of this unit is 19.2 ohms. Overall size is 1.65 inch high with a 2 inch diameter case. Telco Sales Div., Telecomputing Corp. Los Angeles 38, Cal.

Circle No. 156 on Inquiry Card

Hi-Temp Silicon Power Diode

High current silicon power rectifiers provide d-c forward currents up to 250 amperes with a maximum peak inverse voltage range from 50 to 500 volts. They are capable of operation at a junction temperature of 190C and are hermetically sealed to provide reliability in environmental extremes of temperature, vibration and shock. No soft solders or fluxes are used in sealing. International Rectifier, El Segundo, Cal.

Circle No. 236 on Inquiry Card

Miniature Proximity Pickup

Probe-type pickup, a very small sensing unit for proximity control systems, which detects both ferrous and non-ferrous metal parts having a diameter of less than 1/1-inch, can be excited by gear teeth of 10 diametral pitch. Mounted at the point of work, a shielded cable connects the pickup to a proximity control unit. The connected control unit provides an electrical pulse that governs associated mechanical or production operations. This miniature proximity pickup detects stationary and moving metal pieces passing the pickup at a rate up to 60,000 per minute. For metal pieces over 3/8 inch in diameter, operating clearances are up to 1/4 inch. The pickup's high temperature range is up to 200F. The sensing face of the unit is 3/8 inch in diameter; overall length is 2-1/8 inch; mounting thread is 7/16-20. Electro Products Laboratories, Chicago 40, Ill.

Circle No. 163 on Inquiry Card

Gearhead Adapted to Size 8 Motor

Precision servo motor gearhead adapts instantly to size 8 motors with a new style, double-lipped clamp. The new clamp-equipped miniature gearhead is particularly advantageous since present BuOrd style end caps on size 8 servo motors do not have tapped holes for screw mounting gearheads. The motors, however, do have a groove which was used for attaching gearheads with ears, dogs and other multi-part devices. The same groove is used with Bowmar clamp. Loosening or tightening a single screw is the only installation or removal procedure required. The gearhead has been improved through elimination of internal post type construction to increase rigidity and improve vibration and shock resistance, as well as increase accuracy and permanency of component alignment. Bowmar Instrument Corp., Ft. Wayne, Ind.

Circle No. 235 on Inquiry Card

Rugged Limit Switch

Limit switch, designed for any exposed control or indicating application on aircraft or industrial machines, is light and compact yet rugged and impervious to all environmental conditions. Corrosion resistant through use of stainless steel or monel for all exposed parts and heliarc welded for positive sealing, component meets all requirements of Immersion Test MIL-E-5272, Procedure 1. High operating and over-travel forces (9 ± 3 lbs and 30 lbs max. respectively) provide positive ice-breaking characteristics to assure dependable operation. Available in 12 variations. Switch Div., Electrosnap Corp., Chicago, Ill.

Circle No. 224 on Inquiry Card

Miniature Solenoid

Miniature solenoid, produced for maximum weight and space savings operates with a 10 pound load. The stroke is 0.015 inch, with the start of the motion occurring at a maximum of 6 milliseconds and the stroke completed at less than 13 milliseconds from closing circuit. The solenoid requires 20 volts DC at 78F and operates over an ambient temperature range of −65 to +250F. Size of the small unit is only 1.410 inch high with a case diameter of 1.063 inch and rectangular flange with four mounting holes is an integral part of the case. Telco Sales Div., Telecomputing Corp., Los Angeles 38, Cal.

Circle No. 157 on Inquiry Card

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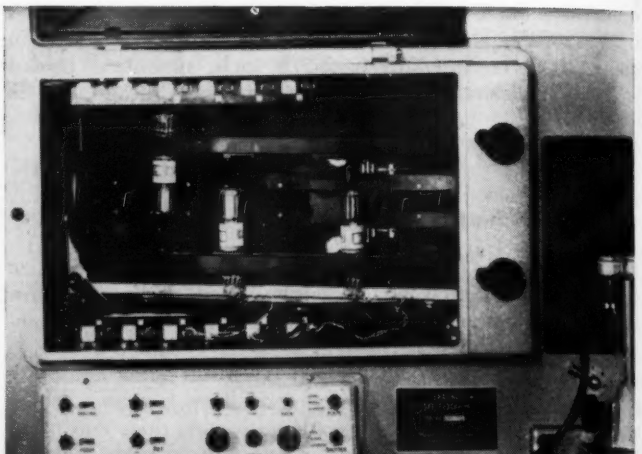
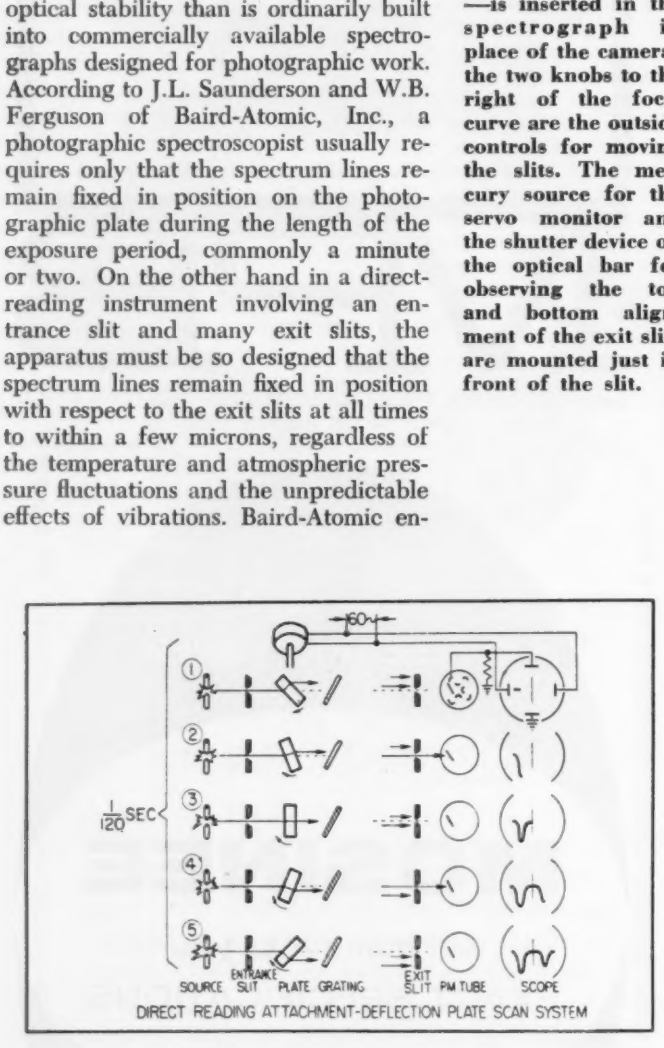
DIRECT READING SPECTROGRAPH

Servo Control Aligns and Stabilizes Spectrum Lines

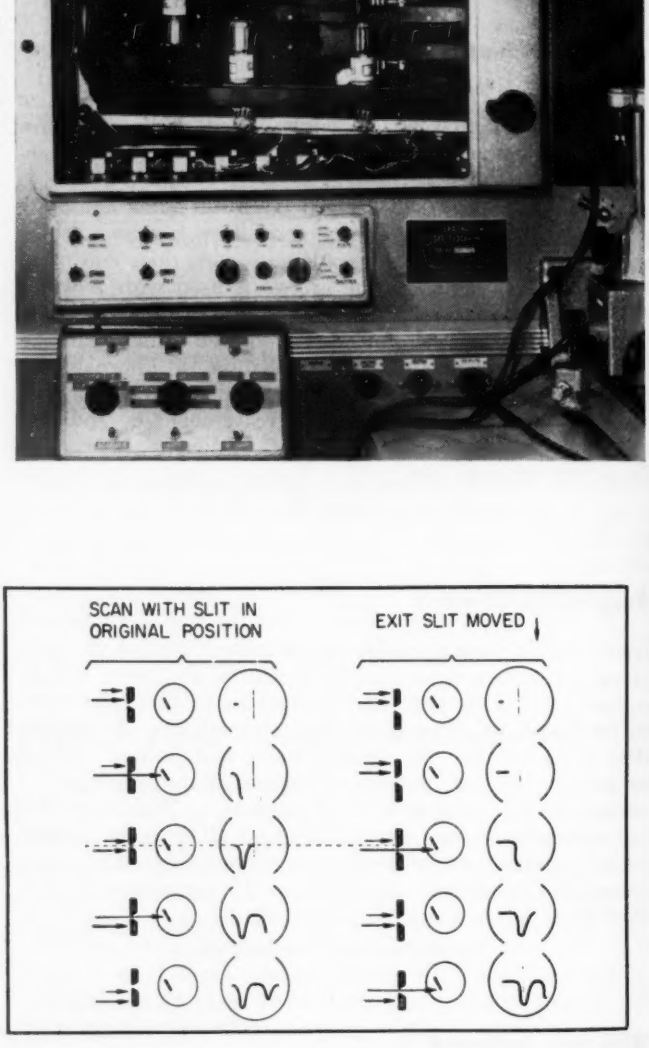
Successful spectro-chemical analysis with equipment of the integrating polychromator type requires much greater optical stability than is ordinarily built into commercially available spectrographs designed for photographic work. According to J.L. Saunderson and W.B. Ferguson of Baird-Atomic, Inc., a photographic spectroscopist usually requires only that the spectrum lines remain fixed in position on the photographic plate during the length of the exposure period, commonly a minute or two. On the other hand in a direct-reading instrument involving an entrance slit and many exit slits, the apparatus must be so designed that the spectrum lines remain fixed in position with respect to the exit slits at all times to within a few microns, regardless of the temperature and atmospheric pressure fluctuations and the unpredictable effects of vibrations. Baird-Atomic en-



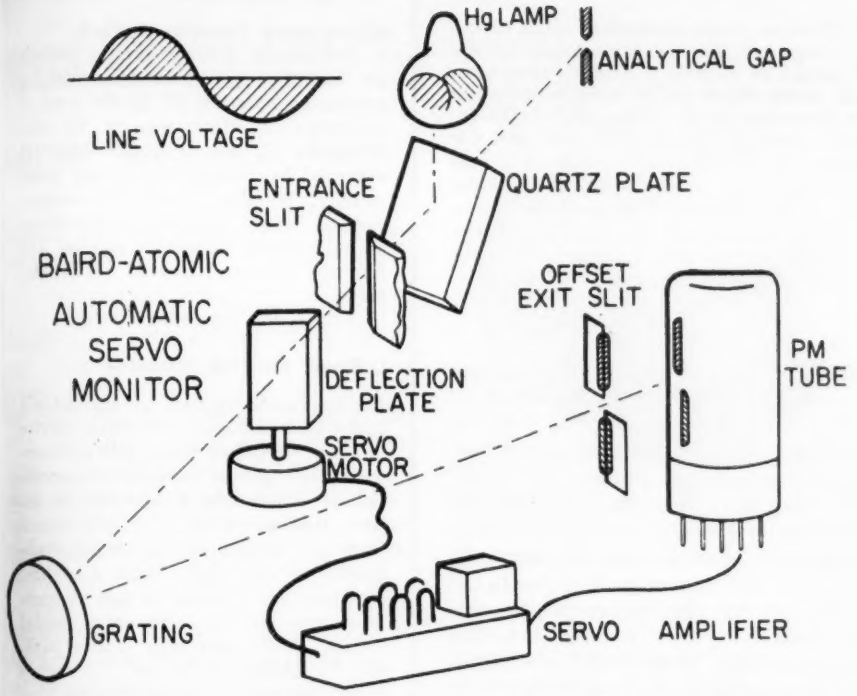
Right photo shows how the direct reading focal curve—the direct reading head—is inserted in the spectrograph in place of the camera; the two knobs to the right of the focal curve are the outside controls for moving the slits. The mercury source for the servo monitor and the shutter device on the optical bar for observing the top and bottom alignment of the exit slits are mounted just in front of the slit.



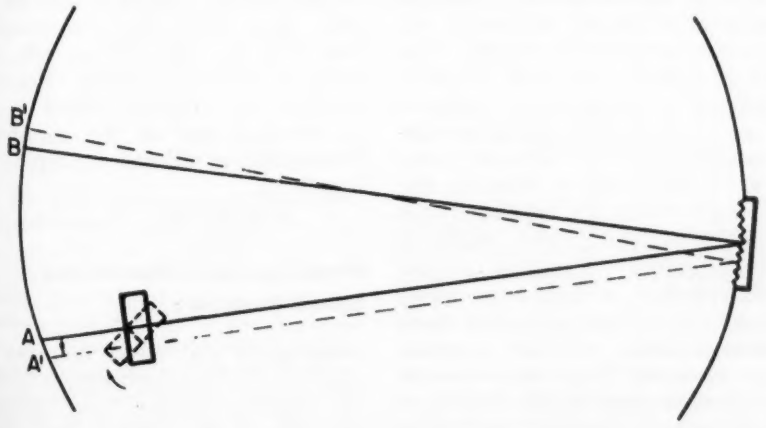
DIRECT READING ATTACHMENT-DEFLECTION PLATE SCAN SYSTEM



Schematic of the spectrograph with its direct reading attachments shows the analytical gap, entrance slit, deflection plate, grating exit slit, and the photomultiplier tube. The tube is connected to the vertical deflection plates of an oscilloscope and the horizontal deflection plates are connected to the 60 cycle line which drives a synchronous motor rotating the deflection plate at 1800 rpm. The five illustrations show successively what happens as the deflection plate rotates. During the 1/120th of a second shown, spinning of the deflection plate causes two spectrum lines indicated by light and dark arrows to be scanned across the exit slit. As they scan across, first one and then the other folds on the photo multiplier tube. At the same time the trace is moving across the face of the scope and the result is a scope presentation of a small portion of the spectrum. Illustration on the left shows how the spectrum line showing on the left of the scope schematic would be used for analysis. In the right illustration the exit slit at the left, photo multiplier, and oscilloscope are shown exactly as in the figure on the left; the slit is now moved in the direction shown by the arrow. The time represented by the center picture is the time in which the trace reaches the scope center; the defletion plate is normal to the beam and the slit has been moved so that the desired spectrum line passes through the slit at this instant. When the trace is completed the desired spectrum line is shown in the scope center. This is the direct reading head which is inserted in the spectrograph in place of a usual plate holder. 20″ of focal curve are



available for the setting of exit slits. Simple schematic illustrates components in the automatic servo monitoring system. In the spectrometer an entrance slit is located near the center of the slide, a concave grading at the lower left corner and an offset exit slit mounted on the focal curve. The inclined quartz plate reflects some of the mercury light into the entrance slit. Within the envelope of this lamp two regions are excited on alternate half cycles of the line voltage. The lamp illuminates the entrance slit in such a way that the mercury spectrum line at 2536 angstrom units is imaged on the focal curve in two vertically distinct sections; the upper one receives light during one half cycle and the lower one during the next half cycle. The upper opening of the offset slit placed on the spectrum line passes the left half of the top portion of the spectrum line, while the right half of the lower portion of the spectrum line is passed by the lower opening of the offset slit. As long as this alignment of the spectrum line and offset slit is maintained, the photo multiplier tube sees equivalent amounts of light on each half cycle. The photo multiplier tube current will then contain no AC component having a frequency the same as that of the mercury lamp supply. If an optical misalignment causes a spectrum line to move laterally, more light of one half cycle than the other half cycle will fall on the tube resulting in an AC component in its output current. This component will be amplified by the phase sensitive servo amplifier and causes the servomotor to rotate the plane parallel quartz deflection plate placed immediately behind the entrance slit to bring the spectrum line back into correct register. The plane parallel quartz plate controls the position of the spectrum line by giving an apparent displacement to the entrance slit.



Here's how the deflection plate functions in the spectrometer design: the entrance slit of the spectrometer is at A and a spectrum line at B. The deflection plate when normal to the beam does not affect the beam until it is rotated as shown by the dotted lines. Each ray is then moved to the side and continues toward the grating parallel to its original path. The result is an apparent shift of the entrance slit to A^1 and a shift of the spectrum line to B^1.

MISSILE ENGINEERING

The "collapsing of time" concept has taken on added significance as a result of the current international situation. In Tucson, Arizona, Hughes has established the Tucson Engineering Laboratory for the purpose of shortening the elapsed time between missile development and its effective tactical use. This activity, established over 2 years ago, has proven that the quasi-simultaneous development and production of missiles can become a feasible reality.

The Tucson Engineering Laboratory is now expanding its scope of operations. Mechanical Engineers, Electrical Engineers, or Physicists who like to work on urgent problems and who have the ability and enthusiasm to constantly improve the product and its reliability, will find this an ideal environment. Specific areas of interest include: missile system analysis, infrared and radar guidance systems, electromechanical and hydraulic control systems, missile and test equipment and electronic circuit design.

An added advantage: Tucson's dry healthful climate. Investigate by sending resume to Mr. W. A. Barnes at:

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HUGHES

TUCSON ENGINEERING LABORATORIES

Hughes Aircraft Company

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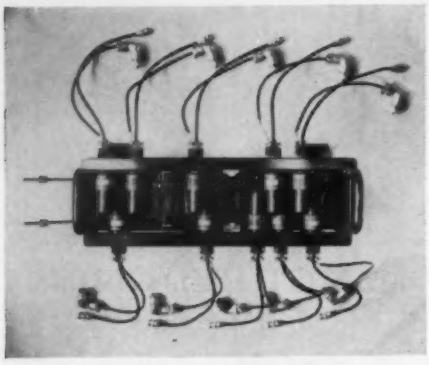

← Sixteen photo multiplier tubes of the RCA type can be accommodated on the two banks of sockets provided; the lower bank holds tubes in an upright position and the upper bank holds tubes in an inverted position. Mechanical linkages for moving the upper and lower half of the exit slits can be seen extending from the right of the direct reading head; these attach to knobs on the outside of the spectrograph and move upper and lower rails extending the length of focal curve.

gineers have now designed a spectrograph that continuously and automatically maintains the alignment of spectrum lines and exit slits to within the required degree of stability. In addition to this requirement, chief considerations in this design were rapidity of interchange between photographic and direct reading work and ease of placing exit slits on the new spectrum lines when setting up a new analytical problem.

The problem was solved with an automatic servo-monitoring system that keeps the spectrum lines in register with the appropriate exit slits. The servo monitor is so sensitive that it corrects for two or three micron displacement of the spectrum. The distance from grating to focal curve is approximately three meters. In terms of an angle, the monitor corrects for deviations of less than one quarter of a second of arc—the equivalent of staying to within a one inch bull's-eye at ten miles.

One of the serious problems in the design of the unit is that of providing for simple and speedy alignment of exit slits by the user of the instrument. Design objectives require an instantaneous monitoring system that allows the operator to keep track of each adjustment to the exit slit as it is made. Alignment of each exit slit must be such that the spectrum line passes the center of the slit; moreover the exit slit must be precisely parallel to the spectrum line. A method for facilitating these adjustments was designed at Dow Chemical Co. and modified by Baird-Atomic; details of the system are described in the schematic.

A spectrograph with a combination direct-reading and photographic unit permits a large volume of routine analytical work to be performed with the direct reading system and allows more time for miscellaneous analytical problems and for exploratory specialized studies with the photographic portion of the instrument.

Circle No. 73 on Inquiry Card

Microwave Ferrite Switch

A low-power X-band ferrite switch for on-off applications provides a minimum isolation of 25 db with a maximum insertion loss of 0.5 db. Multiples of this isolation can be obtained by connecting several units serially. Weight is only 15 ounces; over-all length, 1.7 inches. Raytheon Manufacturing Company, Special Microwave Device Group, Waltham, Mass.

Circle No. 134 on Inquiry Card

L-Band Ferrite Isolator

An improved version of Raytheon's high-power L-band microwave ferrite isolator combines high performance with high power capacity. Constructed of half-height waveguide to reduce size and weight, built-in transitions to full-height guide provide match over the entire band; a cooling structure is available for use at higher power levels. The new model weighs 34 lbs and is 6 inches high, 8-11/16 inches wide and 17 inches long. Minimum transit/receive isolation is 11 db; maximum insertion loss is 0.55 db. Average power-handling capacity is 2½ kilowatts; peak power is 3 megawatts. Raytheon Manufacturing Company, Special Microwave Device Group, Waltham, Massachusetts.

Circle No. 135 on Inquiry Card.

Lightweight Aircraft Transformers

A new line of lightweight, aircraft, power transformers designed to withstand high acceleration and extreme shock is available in ratings from 10 va to 5 kva. 10 percent lighter in weight and 25 percent smaller in volume than previous types, single-phase or three-phase models are offered. Rated 400 cycles, 2500 volts test, they have no resonant points until well above 500 cycles vibration and are shock-tested at 50 gravities. Sealed in form-fit polyester resin cases, they are completely insensitive to high differentials of internal or external pressure. For added strength, the terminal board is made an integral part of the transformer. Westinghouse Electric Corp., Pittsburgh, Pa.

Circle No. 137 on Inquiry Card

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Performance of high temperature accelerometer series, originally designed for extreme environmental conditions encountered in aircraft and missile applications in temperature ranging from −100F to +500F, has been advanced 25 degrees in temperature operation with use of precision building production technique and new Glennite piezoelectric ceramic without changing the instrument's controlled characteristics of ±5% repeatability and sensitivity and ±1% linearity. Designed for continuous operation without temperature compensation or external cooling, these instruments exhibit excellent capabilities at extremely high temperatures. Other characteristics include high resonant frequency, reliability and accuracy and minimum falloff in sensitivity. The units are virtually noise free. Grounded or ungrounded models available. Gulton Instrumentation Div., Gulton Industries, Inc., Metuchen, N.J.

Circle No. 153 on Inquiry Card

Precision Gear Heads and Speed Reducers

Gear heads and speed reducers from size 8 to 18 have high torque transmittal capacity to size ratio; maximum backlash of 30 minutes; will operate from minus 55 to plus 150 degrees C.; conform to all applicable military specifications. Standard units with wide variety of ratios readily available. Synchrosolve, Inc. Brooklyn, New York.

Circle No. 199 on Inquiry Card

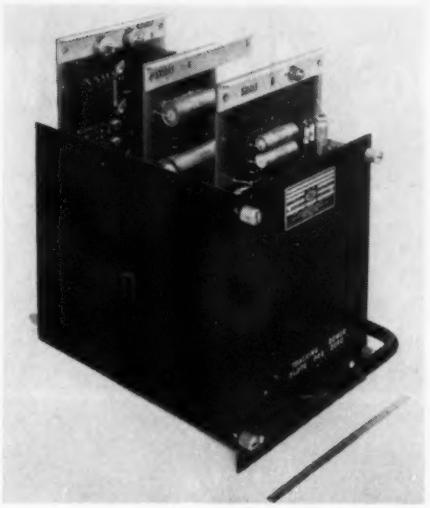
SYSTEMS DESIGN

COPTOR ROTOR REGULATOR

Servo System Maintains Constant Rotor Speed.

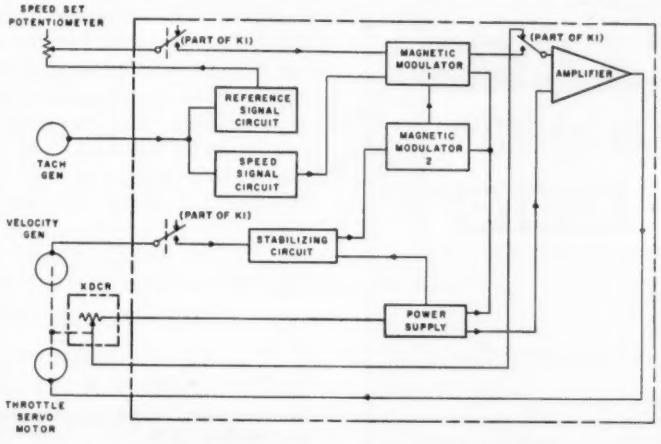
A valuable aid to helicopter pilots, designed for the Sikorski S-58 governor system, maintains helicopter rotor speed constant despite variable loads imposed on the engine during flight. The new unit, called a governor amplifier, converts any deviation from engine speed setting into an error signal and feeds it back to the engine throttle to cancel the deviation. Using transistors and magnetic amplifiers mounted on printed circuit panel boards, the Electronics Department of Hamilton Standard emphasized compactness, reliability and conformance to MIL specifications in the design.

Weighing only 5¼ pounds, the governor amplifier houses the various assemblies, subassemblies, and parts in a cabinet 7½ inches high, 5½ inches wide, and 10⅞ inches deep. It is constructed for installation in standard mounting racks and requires neither shock nor vibration protection, since it is capable of operation at vibration levels specified in MIL E-5272. Electrical connection to the governor amplifier is made by means of a 32-pin receptacle located at the rear of the cabinet. Four potentiometers, used for initial circuit adjustment, are located behind the cover plate on the front panel.



Hamilton Standard Governor Amplifier Circuitry of the system is divided into three functional sections. Heavier components are mounted on the chassis; all others are mounted in plug-in-panels, shown partially extended in the photograph. These replaceable panels make routine service a simple matter. The block diagram shows the functional sections of the unit and their connections to elements of the engine governor system.

Circle 72 on Inquiry Card.



Block Diagram of Governor Amplifier. A tachometer-generator driven by the engine supplies an a-c signal into the speed signal circuit of the governor amplifier. This signal is converted to a d-c voltage and applied as one input to a magnetic modulator. In addition, the a-c signal from the tachometer-generator is applied to the reference signal circuit where it is converted to d-c and controlled in amplitude by setting of the speed-set potentiometer (pilot's speed-selector). This reference signal is applied as a second input to the magnetic modulator, and the resultant amplitude modulates a 400-cycle signal accordingly. This 400-cycle signal (or error signal) from the magnetic modulator is then amplified and applied to the control windings of a servo-motor, which increases or decreases the engine speed dependent upon the phase of the servo-motor control signal. To provide stability in the control system, a feedback signal proportional to the rate of change of the error signal is added to the error signal. When it is desired to remove the control action of the governor amplifier from the governor system, an externally mounted toggle switch is closed. This energized relay K_1 which opens the 400-cycle error circuit and cuts in a transducer (XDCR) working in conjunction with a preset potentiometer. The latter generates a signal which drives the servo-motor until its trunnion positions the throttle at its midpoint (a neutral position).

HYPSOMETER RADIOSONDE

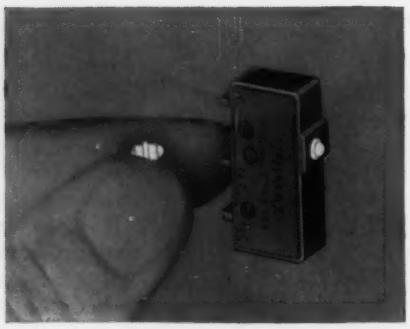
Liquid-Filled Vacuum Bottle Measures High-Altitude Pressure

A "super-accurate" electronic weather detector uses a liquid-filled miniature vacuum bottle to measure atmospheric pressures in the upper altitudes with 5 to 10 times the accuracy possible with existing instruments. Developed by the U.S. Army Signal Engineering Laboratories at Forth Monmouth, New Jersey, the instrument known as the hypsometer radiosonde is being produced by the General Instrument Corporation of Newark, New Jersey, under "Project Jupiter", and will be sent aloft in weather balloons to help the Armed Services ferret weather secrets 15 to 25 miles above key ballistic missile launching sites.

Based on an ancient principle of measuring altitude by the boiling point of a liquid, the hypsometer "takes over" from pressure bellows to measure atmospheric pressures at heights of 15 miles and up—and where the faint pressures make bellows devices inaccurate. Physically, the hypsometer—from the Greek: *hupsos*, height—is a two inch vacuum flask filled with 5 cubic centimeters of a commercial solvent, carbon disulphide, which boils at very low pressures and temperatures. When the balloon reaches approximately 60,000 feet altitude, the liquid inside the flask boils spontaneously and as the balloon rises into ever-thinner air, the temperature of the boiled-off vapor goes down rapidly. A thin fishhook-like thermistor inserted into the neck of the flask takes continuous readings of these "inside" temperatures and telemetry equipment transmits these readings along with outside air temperature measurements back to ground. Given the outside and inside-the-flask temperatures, ground-based missile metereologists can compute almost instantly both atmospheric pressure and altitude. Ground tracking devices can track the signals from the radiosonde for wind direction and velocity measurements. This data feeds into computers which give an on-the-spot evaluation of weather conditions above the missile site. Accurate, high-altitude readings made possible by the system should permit military weathermen: 1) to judge conditions for a missile rocket or satellite launching with far greater margin of safety and 2) to indicate more precisely to the missile's "brain" what weather can be expected in flight. Eventually, the device may be used for general weathercasting.

Circle No. 70 on Inquiry Card

PRECISION



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CIRCLE 19 ON INQUIRY CARD

Hi-Temp Silicon Voltage Regulators For Hi-Voltage

Smaller, lightweight, more rugged voltage regulation circuits can now be designed through use of silicon zener voltage regulators in place of such conventional gas tube regulator types as the OA2, OA3, OB2, OC3, IB46 and the 991. This series of 5-watt rated (without heat sink) regulators enable the design engineer to specify *any* zener voltage for his exacting circuit requirements in the range from 24 to 160 volts. In addition, Style HZ silicon regulators are designed to provide substantially lower dynamic resistance than comparable tube types over a broad temperature range from −65C to +165C.

Extremely high zener reference voltage and low dynamic resistance of these multiple junction units is due to their unique construction. A series of matched and selected low-voltage zener diodes are mounted and securely interconnected within an oil-filled housing designed to provide very low thermal resistance. Each junction is hermetically sealed to insure no contamination and maximum reliability. Internat'l. Rectifier Corp., El Segundo, Cal.

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Low-Noise UHF Amplifiers

Two-stage grounded-grid amplifiers feature low-noise figure, excellent R-F shielding and simplified tube replacement. The Western Electric 6280 coplanar triode is used in a special socket which offers mechanical rigidity, efficient cooling, and one-step disassembly for tube removal. The amplifiers, with either cavity-type or line-type interstage and output coupling, also supplied with IF conversion to 30 or 60 Mc. Ewen Knight Corp., Needham Hts., Mass.

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WORTH FILING

Servoboard Electro-mechanical Assembly Kit

New 16-page catalog provides complete features and specifications on all Servoboard (registered trademark) electro-mechanical assembly components. Included are mounting components, component hangers, component clamps, bearing hangers, shaft components, gears, service units, limit stops, switch assemblies and clutches and differentials. All these precision parts may be purchased individually in production lots or in 4 types of kits. Complete contents of each are detailed in the catalog.

Source: Servo Corp. of America
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For your copy: Circle No. 192 on Inquiry Card

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SV-54 Series

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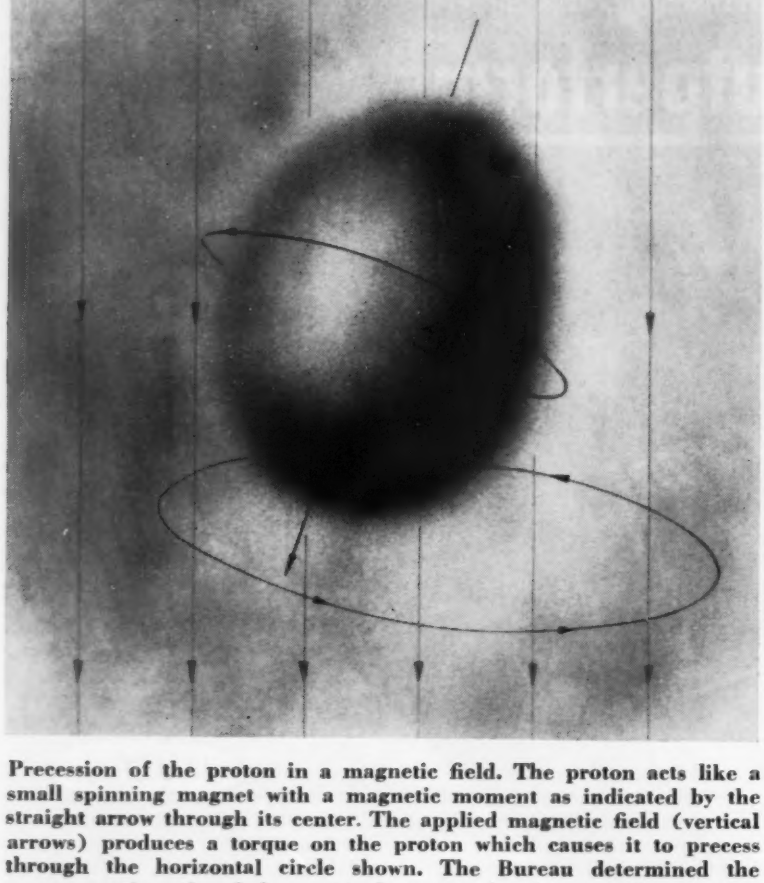
VALCOR SOLENOID VALVES

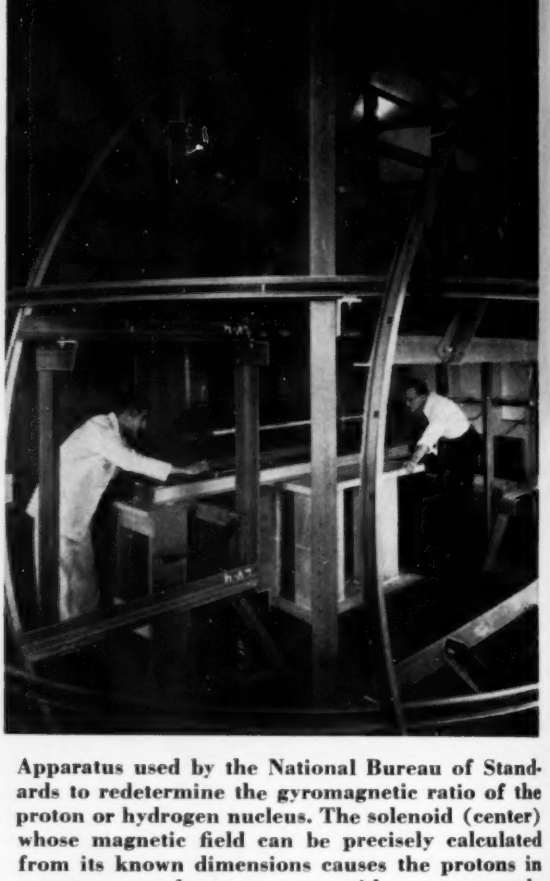
VALCOR ENGINEERING CORP.

5374 Carnegie Avenue, Kenilworth, New Jersey

CIRCLE 9 ON INQUIRY CARD



Precession of the proton in a magnetic field. The proton acts like a small spinning magnet with a magnetic moment as indicated by the straight arrow through its center. The applied magnetic field (vertical arrows) produces a torque on the proton which causes it to precess through the horizontal circle shown. The Bureau determined the gyromagnetic ratio of the proton by measuring its rate of precession in a magnetic field of known strength.



Apparatus used by the National Bureau of Standards to redetermine the gyromagnetic ratio of the proton or hydrogen nucleus. The solenoid (center) whose magnetic field can be precisely calculated from its known dimensions causes the protons in a water sample to precess with an accurately measurable frequency. Proton gyromagnetic ratio is then calculated from the precession frequency and the precisely known field strength. The large coils which surround the apparatus counterbalance the earth's magnetic field.

GYROMAGNETIC RATIO OF PROTON

New Measurement Technique Improves Accuracy by Factor of Four

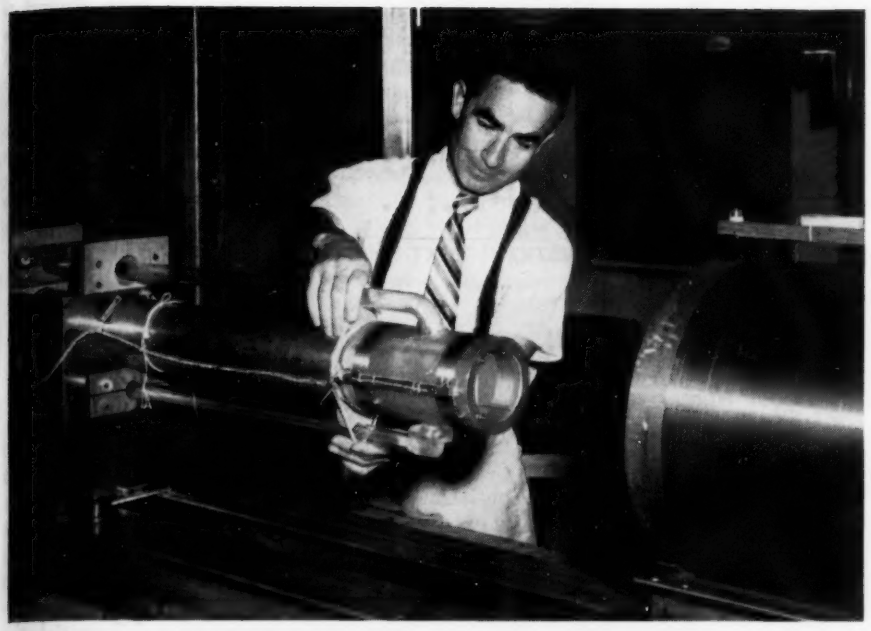
Gyromagnetic ratio of the proton—a measure of its interaction with magnetic fields—has been redetermined with significant increase in accuracy. This result not only provides a better standard for magnetic fields but also makes possible more accurate values for many of the fundamental constants of physics whose values depend upon magnetic field measurements. Examples are the electron charge-to-mass ratio e/m, the magnetic moment of the proton, and Planck's constant h.

Redetermination was made by R. L. Driscoll and P. L. Bender of the National Bureau of Standards using facilities provided by the Fredericksburg Magnetic Observatory of the U. S. Coast and Geodetic Survey.

The new value for the proton's gyromagnetic ratio will be especially useful in design and development of scientific and industrial apparatus in which it is important to know accurately the spatial distribution of a magnetic field or to regulate it closely. Here the proton can be used as a very sensitive probe to determine magnetic intensity in terms of the precisely known gyromagnetic ratio. Problems of this sort arise widely in use of scientific apparatus—cyclotrons, mass spectrographs, and beta-ray spectrometers—and in industrial equipment such as servo mechanisms and electromagnets.

Like other atomic nuclei, the proton, or hydrogen nucleus, behaves as a small magnet. When placed in a magnetic field, it tends to orient its axis along the direction of the field. However, the proton is also spinning rapidly about its axis, and the resulting angular momentum causes it to act like a gyroscope. Thus, instead of lining up with the field, the proton actually precesses about the field direction. Ratio of angular precession frequency to magnetic field strength gives the gyromagnetic ratio.

In 1949 the gyromagnetic ratio was determined by measuring the magnetic field and radio frequency required for magnetic resonance absorption in hydrogen nuclei contained in a water sample. A strong magnetic field of about 5000 gausses was used, and its value was determined by finding the force exerted by the magnetic field on a wire carrying a known current. This magnetic field measurement was



Compensating coils for making the magnetic field about the proton sample more homogeneous. Solenoid (right) has been moved aside. Above the compensating coils is the pneumatic tube used to carry the sample into the solenoid.

difficult and was the principal limitation on accuracy of the result obtained.

The new method reduced the error of the earlier one by a factor of four by using simpler techniques that have been developed since 1949. In this method NBS scientists caused the hydrogen protons in a water sample to precess in a magnetic field, and obtained the precession rate from the frequency of voltage induced in a pickup coil surrounding the sample. They then determined the gyromagnetic ratio as the ratio of angular precession frequency to field strength.

The experimenters achieved increased accuracy by using a magnetic field that could be calculated to a very high precision. They produced this field by an accurately measured current flowing through a solenoid whose important dimensions were known to one part in a million. However, since the field strength obtained in this way was only 12 gausses, spurious magnetic fields from other apparatus, electrical currents, or vehicles had to be carefully avoided. For this reason, the measurements were carried out at the Fredericksburg Magnetic Observatory of the U. S. Coast and Geodetic Survey, in a non-magnetic building with large coils for compensating the earth's magnetic field.

Distilled water contained in a glass sphere about 2 cm in diameter was used as the proton sample. They placed the sample in a strong magnetic field to build up a large magnetization of the protons along the direction of the magnetic field. They then shot the sample about 15 meters through a pneumatic tube into the center of the solenoid, within the nonmagnetic building. With the sample in the solenoid, they applied a short pulse of radio-frequency magnetic field near the precession frequency to tip the magnetic moments of the protons making them nearly perpendicular to the magnetic direction. The protons then precessed about the magnetic field direction at a frequency corresponding to the strength of the field. Flux through a pick-up coil surrounding the sample changed at the same frequency at which the magnetization of the sample was precessing. Finally, the NBS scientists measured the frequency of the induced voltage across the pick-up coil accurately against standard frequency broadcasts by the Bureau's radio station, WWV, and combined the resulting value with the magnetic field strength to give the proton gyromagnetic ratio.

They obtained a preliminary value of $(2.67515 \pm .00001) \times 10^4$ radians/(sec gauss), uncorrected for diamagnetism of the water sample, for the proton gyromagnetic ratio in terms of the ampere as now maintained at the Bureau. The value obtained in 1949 was given as $(2.67523 \pm 0.00006) \times 10^4$ radians/(sec gauss). If the present result is combined with a recent determination of the ampere as maintained at the Bureau in absolute units, the value becomes $(2.67513 \pm .00002) \times 10^4$ radians/(sec gauss).

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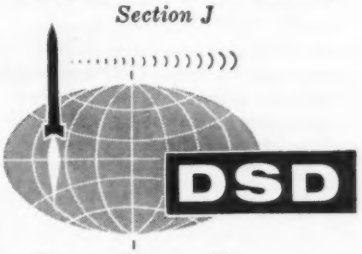

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CIRCLE 4 ON INQUIRY CARD

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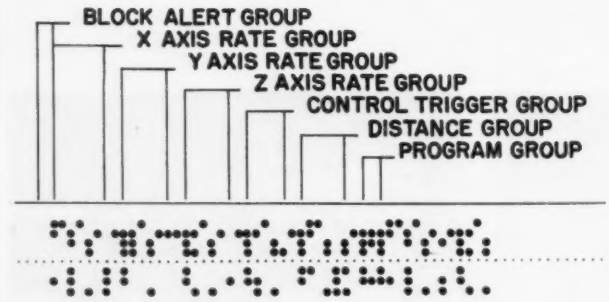


Magnetic tape signals represent dimensional and machining information from blueprints supplemented by data from production. Two thousand feet of tape furnish two hours of machine time; each track corresponds to a specific machine axis or action; reference track serves as a time base for the complete system.

FLEXIBLE AUTOMATION

Low Cost Numerical Control for Machine Tools

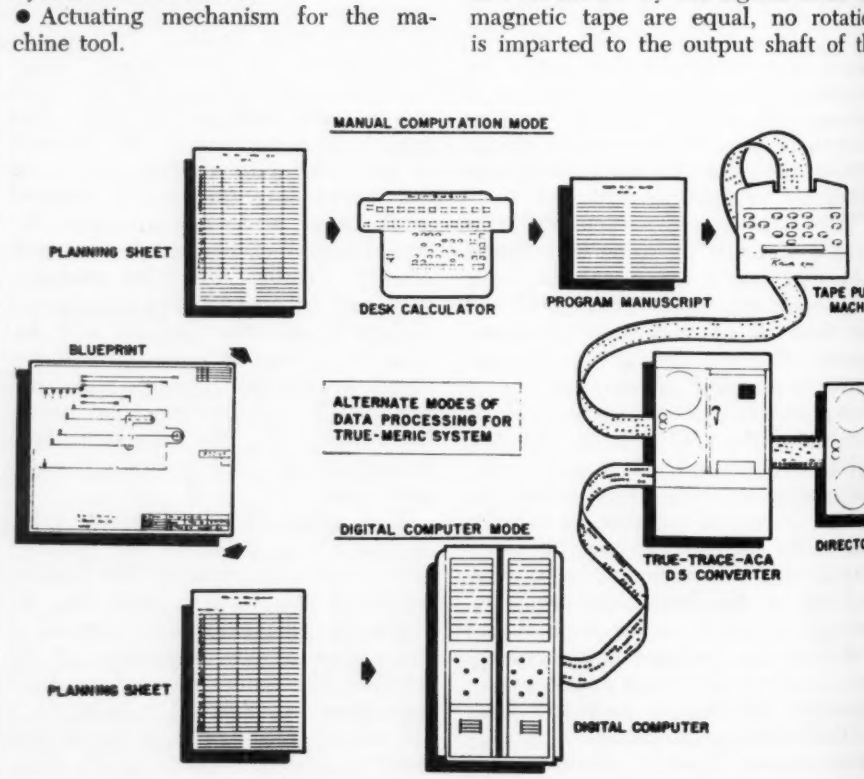
For more than a decade automation has held out the enticing promise of lower costs and higher profits. But the accent on high speed, low cost production for large runs has changed over the years; now, the accent is on flexible automation—applying added production capability to low quantity operations. To meet this need True-Trace has joined in forming the Automation Corporation of America to supply industry just such equipment. The True-Trace system consists of three separate portions:

- Command information in the form of magnetic tape.
- Control element which transforms magnetic impulses to actuate precision hydraulic servo valves.
- Actuating mechanism for the machine tool.

DRIVE MECHANISM

The control motor varies the rate and directional sense of the lead-screw. To accomplish this control without incurring the inaccuracies and problems usually associated with speed and direction control of electric motors, the reference and control motors were coupled by means of a differential, the output shaft of which drives the lead-screw. Instead of requiring the control motor to be varied in speed from zero to maximum rate and undergo stopping and reversing actions for full range of rotation to the lead-screw, the motor-differential combination permits the motors to be run at speeds near their optimum design value and in one direction only.

When the rates of rotation imparted to both motors by the signals from the magnetic tape are equal, no rotation is imparted to the output shaft of the



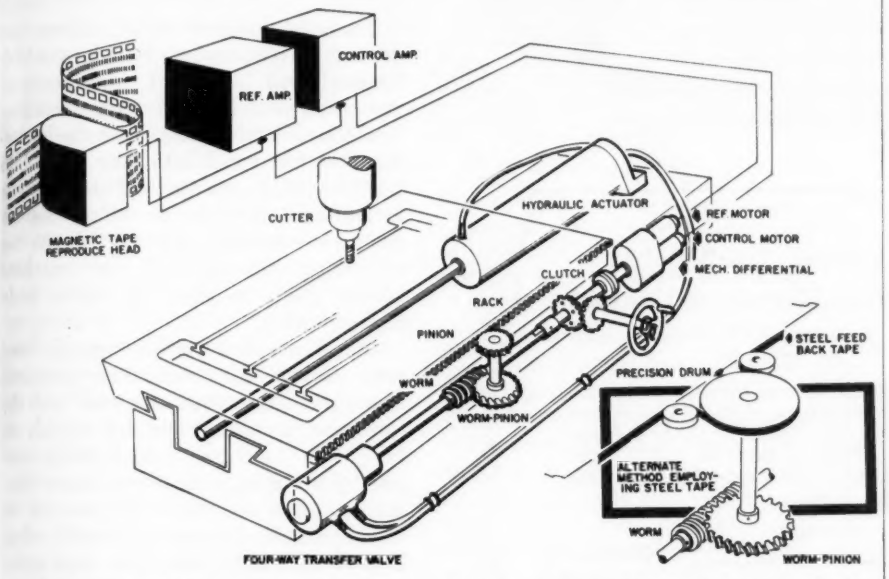
Block diagram illustrates the flow of information from the original blueprint to the machine director. Two modes of operation are possible: one uses normal computation of machine commands; another a digital computer.

differential. When the rate of rotation of the control motor is higher than that of the reference motor, the output shaft is turned in one direction. When the rate of rotation of the control motor is lower than that of the reference motor, the output shaft is turned in the opposite direction.

Thus the speed of the differential output shaft is set by the difference in rotation rates of the two motors, while the direction of rotation is determined by whether the control motor speed is above or below that of the reference motor. Important factors in this shaft speed control are operation of the motors at or near their design speeds and elimination of requirements for reversing the motor's rotation. This procedure reduces inertial loads which might result in slippage and similar errors in the system. At the same time, operation of the motors in their optimum speed range extends their life.

Spacing of the pulses on the magnetic tape sets the frequency of the signals to the motors, while the total number of pulses determines the total amount of rotation of the motor. This approach to tape control of motor speed and rotation, coupled with the use of the reference track and motor, provides the system with a time base independent of external effects. Since rotation depends on the total number of pulses on the tape, the motors cannot rotate through any number of revolutions other than that set on the tape. This insures that the amount of rotation of the differential output shaft is not affected by changes in tape speed, loading of the machine traversing mechanism, or variations in power line frequency. The rate of rotation may be affected, but the total rotation which dictates the travel of the machine remains fixed at the value set on the tape.

In addition, by adjusting the rate at which the magnetic tape passes the read-out heads, the machine operator can vary the machine feed speeds by



For rack and pinion feed applications a simple feedback technique based on mechanical principles was utilized. In this mechanism the worm gear driven by the output shaft of the mechanical differential has a limited amount of translational motion by splining the worm gear to the mechanical differential shaft. As the splines drive the worm gear in rotational motion the worm gear can move longitudinally with respect to the differential output shaft and the bed of the machine. Free end of the worm gear bears against the spool of the spring loaded, 4-way transfer valve. As the worm gear moves longitudinally the spool follows its motion and is displaced with respect to the body of the valve. The worm driven pinion is coupled by a solid shaft to the pinion engaging a rack. It cannot rotate unless the rack is moving so as to provide its pinion with its equivalent rotational freedom. Rotation of the worm gear causes its helix to bear against the teeth of the pinion and results in longitudinal motion of the worm. This motion displaces the spool of the four-way valve with respect to its body and opens the porting. Fixed to the transversing portion of the machine, the rack moves with the machine and drives the pinion gear. This rotation coupled to the worm gear pinion causes it to rotate and is the nature of the precise feed-back action. As the traversing portion of the machine duplicates the motion commanded by the worm gear, it takes up the relative displacement of the worm gear and its pinion, removing the bearingforce between the two elements. As this force is removed, the spring action on the spool turns the valve to a closed position and stops the feed motion. In this manner the feed-back concept has insured that the machine has traversed an exact amount coded on the magnetic tape.

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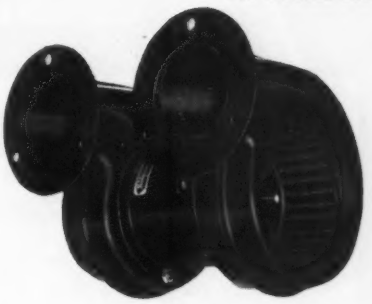
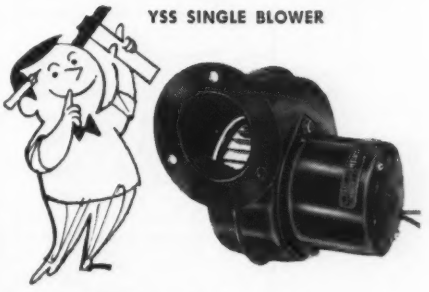


YS BLOWERS

YSS SINGLE BLOWER



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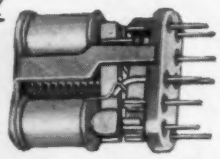

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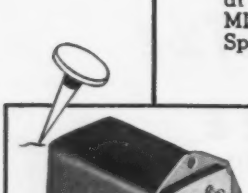
3 Amp Double Pole, Double Throw. Meets or surpasses requirements for all specifications of MIL-R-25018 and MIL-R-5757C. No exceptions. Contact Rating: 3 Amps at 125° C. per MIL-R-25018; 2 Amps at 125° C. per MIL-R-25018 and MIL-R-5757C Hermetically sealed. Specify plug-in or solder hooks.



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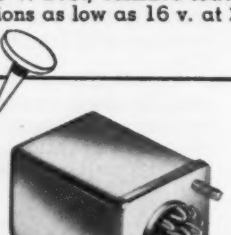

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10 Amp 4 Pole, Double Throw aircraft and missile relay uses same size envelope as AN 3304 (4 P.D.T. 3 Amp relay) and is approximately the same weight. Designed to meet and exceed test requirements of MIL-R-6106B, Class B. Meets minimum current requirements of military specifications.

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CIRCLE 2 ON INQUIRY CARD

±20 percent to allow for any special operating conditions. Manual feed mechanisms in the lead-screw and rack and pinion configurations permit the operator to position the work piece and to operate the machine independently of tape commands. Designers made this possible by placing the magnetic clutch between the output shaft of the differential and the lead-screw. For manual operation, the clutch is disengaged, and the lead-screw turned by a hand drive wheel.

FEED MECHANISM

Differential output shaft drives the precision lead-screw which controls forward and backward movements of the spool of a four-way transfer valve. The transfer valve translates the movement of the spool into flow rates into the hydraulic actuator that governs the extent and the rate at which the actuator is extended or retracted. As the traversing portion of the machine moves along its axes, the valve body moves with it.

In essence the system controls feed rate rather than machine position. However, since both the rate and the time are accurately set by signals on tape, the machine accomplishes precise positioning. In multi-axes machines, each machine axis carries its own hydraulic actuators, transfer valve, lead-screw mechanism (or equivalent rack and pinion mechanism) and motor-differential combination.

Circle No. 53 on Inquiry Card

Cor-bond Electrical Contacts

A new type of electrical contact is made on automatic machines from a special rod stock containinng a firmly bonded core of a suitable contact material, which may be fine silver, coin silver, gold, palladium, or any one of a number of special alloys. The body material is usually free-machining yellow brass, although other materials can be used when required.

The contacts are produced in one operation which is completed when the core is upset and formed to make the contact face. This hardens the face and provides a smooth burnished surface. Since there is no brazing, no annealing or distortion results.

Almost any part that can be produced on a screw machine can be made into a Cor-bond contact. This includes all types of screw contacts, as well as special shapes for embedment into plastic supports, small contact parts for miniature and subminiature relays and switches. Fansteel Metallurgical Corporation, North Chicago, Illinois.

Circle No. 104 on Inquiry Card

ELECTROSTRICTIVE CERAMICS

Applied Voltage Generates Radial Mechanical Displacement

Discoveries in electrostrictive ceramics have resulted in design of exceptionally low-cost, reliable meter indicators for electrical instrumentation systems. The Mullenbach Division of Electric Machinery Mfg. Company, Los Angeles, who developed the new ceramics, is supplying them in experimental quantities to companies and government agencies interested in taking advantage of their unique characteristics.

The meter indicator is one of a number of unique applications being tested. In the meter design, two sensitive discs enclose a reservoir of oil, or other fluid. Each disc is composed of a silver coated ceramic bonded to a reaction member of metal or glass. When an electrical potential is applied across the ceramic, it contracts radially. The result is a cupping effect on the reaction member (Fig. 1) which compresses the oil reservoir and changes the oil level in a transparent capillary tube (Fig. 2).

Preliminary design indicated that up to ten such indicators could be compressed into an instrument box measuring less than six inches in length. The indicators would be extremely sensitive to even minute changes in the signal voltage, yet would be resistant to shock and vibration.

Mullenbach ceramics are cast and fired in thin sheets, a few thousandths of an inch thick. A silver frit is fused to both sides to provide a capacitor structure. Leads may be soldered directly to the silver coating. The ceramic is bonded to metal or glass with an epoxy adhesive to form an electromechanical device that is similar in concept to the bi-metallic reaction members used in thermostats.

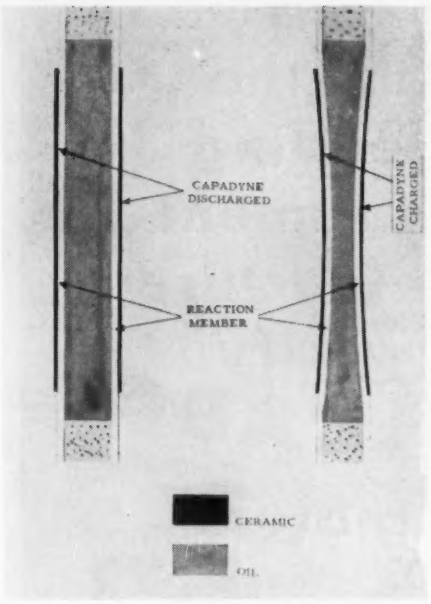

Fig. 1 Electrostrictive ceramics contract in response to electrical field squeezing oil reservoir. This effect can be used in meter indicators shown in Fig. 2.

Principal ingredient in the ceramic is barium titanate, a common compound used in a variety of piezoelectric applications, such as oscillators, sonar transducers, and accelerometers. Mullenbach chemists discovered that by suitable additives and processing techniques, they could inhibit the piezoelectric effect, which is linear and polar, and emphasize an electrostrictive response inherent in the material. Electromechanical action resulting from electrostriction is proportional to the square of the applied field, and is independent of its direction. At the same time, Mullenbach researchers found they could also reduce the effect of Curie-Point crystal changes, resulting in a material substantially free of temperature limitations.

Most important, electromechanical response of the ceramic is instantaneous (within microseconds).

Circle 71 on Inquiry Card.

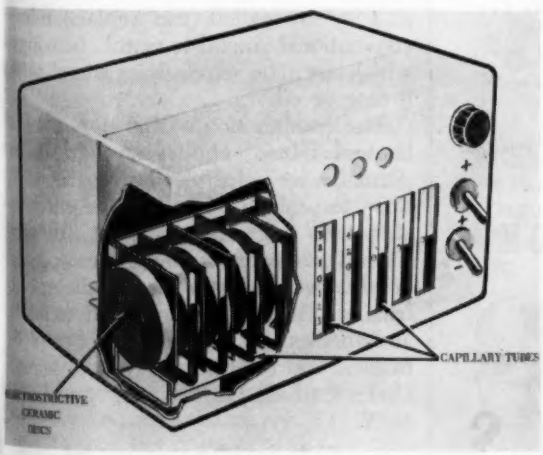

Fig. 2 Application of electrostrictive ceramics to design of a rugged but sensitive meter package.

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CIRCLE 11 ON INQUIRY CARD

Gyro Bearing Lubrication

New ball retainer provides improved lubrication for gyro rotor bearings in inertial guidance systems, while drastically reducing oil mass shifts that induce navigational errors. The problem of minimizing oil mass shifts was solved by designing a ball bearing retainer sintered from a finely divided nylon powder which is then impregnated under vacuum with an instrument oil. Known as Nysorb, this plastic retainer holds sufficient lubricant in its pores to operate the bearing at high speed for long periods. Since oil is distributed evenly throughout the retainer structure, there is little lubricant mass shift to unbalance a delicate guidance mechanism. Nysorb uniformly retains 20 to 25 percent of its own weight of oil even under acceleration of over 800 g's. In tests, many bearings with oil-impregnated Nysorb retainers as their sole lubricant supply have operated without loss of performance for more than 5,000 hours under particularly severe preload and speed conditions. Under comparable test conditions, bearings with conventional phenolic retainers had an effective operating cycle of less than 200 hours. Nysorb retainers absorb 10 to 20 times as much oil as conventional retainers. The Barden Corp., Danbury, Conn.

Circle No. 155 on Inquiry Card

Plastic-Impregnated Bearings Need No Lubrication

A bearing made of fabric impregnated with Bakelite phenolic plastic eliminates need for lubrication of bearings in mechanical applications ranging from miniature instruments to hydroelectric stations. In some instances, such bearings have outlasted the life of conventional metal bearings by as much as eight times. Ruslon bearings, as they are called, can replace many conventional metal-to-metal bearings, which must be regularly serviced with grease or oil.

The combination of Bakelite phenolic and fabric supplies strength in a permanently infusible form. In addition, the phenolic is lightweight, resistant to high temperatures, dimensionally stable under most atmospheric conditions and has a low coefficient of friction. The bearings are inert to acids and alkalies and are not subject to electrolysis or corrosion by salt water. Union Carbide Plastics Co., New York, N. Y.

Circle No. 238 on Inquiry Card

New Process Speeds Engineering and Fabrication of Prototype Cams

By using an automatic computer for much of the usual preparatory engineering, Cam Engineering is able to fashion prototype cams more quickly than has been possible previously. To produce a finished cam, the new process needs only the points on the cam surface dictated by the application. Cam contour is automatically computed to give near-optimum dynamic characteristics consistent with passage through the specified points. The data are then fed to a servo-controlled machine tool which cuts the finished cam. Fabricating the cams on a service basis, Cam Engineering requires only the follower and hub dimensions in addition to the timing diagram coordinates and delivery of the finished cam can usually be made within 48 hours. The system, suited to the making of face, cylindrical and disc cams, is particularly adapted to cams for high-speed applications. Cam Engineering, Div. of Howard Holmes, Inc., White Plains, New York.

Circle No. 206 on Inquiry Card

WORTH FILING

Gyro Handbook

Unquestionably a significant contribution to gyroscopic literature, this handbook describes the Reeves series of floated, single-degree-of-freedom controlled units including integrating gyros, rate gyros, and linear and angular accelerometers for application and use in space stabilization systems, inertial navigation systems, and measurement and control systems. The first part gives detailed theory and applications of integrating gyros; the second and third parts cover theory and application of rate gyros and accelerometers; the fourth section lists detail specifications of gyros and accelerometers. Material in the handbook is organized as a working reference text for design engineers in this field.

Source: Reeves Instrument Corporation
Garden City, New York
For your copy: Circle No. 181 on Inquiry Card

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Circle 150 on Inquiry Card

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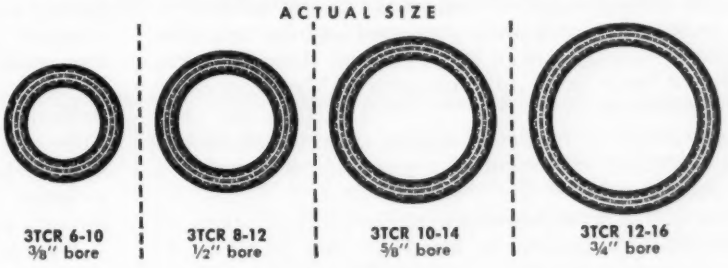

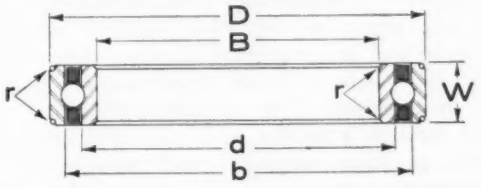

*B bore ± .0002	*D o.d. + .0000 − .0004	W width + .0000 − .0050	†r radius	b outer land ± .001	d inner land ± .001	Balls no.	Balls size	‡L lbs.	§S lbs.
.3750	.6250	.15625	.010	.542	.457	16	1/16	77	110
.5000	.7500	.15625	.010	.672	.587	21	1/16	89	144
.6250	.8750	.15625	.010	.797	.712	24	1/16	94	165
.7500	1.0000	.15625	.010	.922	.8375	30	1/16	101	206

Dimensions are in inches. *Tolerances shown are for Precision Grade. Write for Ultra Precision Grade tolerances. †r is maximum fillet radius on shaft or housing that bearing will clear. ‡Radial load capacity at 500 rpm and 2500 hours average life. §Static non-Brinell load capacity.

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CIRCLE 15 ON INQUIRY CARD

MATERIALS

STAFF COLUMNIST

David Bandel
Associate Technical Director,
TRACERLAB, INC.

RADIATION AND MATERIALS

Radiation and matter interact in a number of basic ways, each of which applied properly can accomplish something useful. In previous columns, I considered several applications—tracing, ionization and static elimination, analysis or trace impurities and radiography. The principle application of alpha radiation of interest to electromechanical engineers is in static elimination, discussed in the June 1958 issue. Here I'll cover interactions of beta and gamma radiation with matter.

BETA RADIATION

Beta particles are electrons. The relatively small mass and size of these particles gives a greater velocity and range than alpha particles for a given energy. In addition, interaction of beta radiation with matter is more complex than that of alpha radiation. Beta radiation passes through matter to a predictable degree. Attenuation of beta radiation as it passes through matter is a function of incident energy of radiation, atomic number of constituent atoms of the matter, density and thickness . . . the latter two factors are usually multiplied to give the weight per unit area, expressed as mg/cm^2. The degree of transmission of beta radiation through matter follows a fairly good approximation of the exponential absorption law: $I_t/I_o = e^{-ut}$, where I_t/I_o is the ratio of transmitted to incident radiation, u is the characteristic absorption coefficient of a given material and t is the thickness.

One of the most important technical applications of radiation, beta gaging, is based on this principle. If we interpose a material of essentially uniform density, such as plastic film, paper, or any sheet material between a beta source and an ionization chamber detection head, variation in beta radiation transmission will be a reflection in thickness. The ionization chamber current is passed through a resistor and converted into a potential drop, in turn, amplified and measured.

The same principle is used in density gaging. Here the thickness is fixed by some sort of cell or pipe and variations in transmitted radiation reflect variations in the density of liquid, gas or slurry flowing through the system. Where corrosive and abrasive materials are handled, the non-contact feature is advantageous.

Beta radiation is also scattered when it interacts with matter. Beta scattering is a function of radiation energy up to 0.6 Mev, the atomic number of elements in the material and thickness of the material. Backscattering increases with thickness up to the point where the thickness is 1/3 the range of the beta radiation in that material, when saturation is attained and no increase in backscattered intensity is obtained past this point.

Backscattering can be used to gage thickness of plate and overlays if the materials differ sufficiently in density. Typical examples: tin plate on iron and zinc or cadmium dipped metal sheet. Backscattering is also used in more conventional gaging applications where the absorption type gage is not feasible. In this case, radiation passes through the material being gaged, reflects from a fixed metal surface and passes through the material once more before entering the detector head. Geometry of the system must be maintained within fairly close limits of tolerance to avoid large errors introduced by changes in geometry of the radiation-detection path.

Beta radiation produces secondary radiation, known as Bremsstrahlung, when beta particles are slowed down in materials with out transferring energy by collision. Bremsstrahlung radiation, electromagnetic in nature and similar to low energy or soft x-rays, is more penetrating than the beta particles. Its intensity increases with increasing energy of the incident beta radiation. Shielding calculations for beta radiation must include additional requirements for Bremsstrahlung. Bremsstrahlung have the proper degree of penetration for use as radiatior sources for sheet metal in certain thickness ranges. However, practical sources of this type of radiation are difficult to produce and most gaging in this range is done with the more complex low voltage x-ray tube sources.

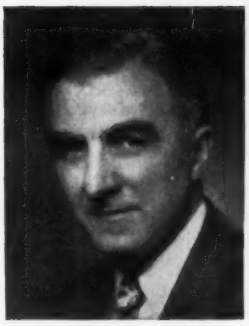
GAMMA RADIATION

Gamma radiation is electromagnetic in nature and interacts with matter in a manner reflecting this characteristic. Absorption of gamma rays follows more closely the exponential absorption law stated in the section on beta radiation, though the range of gamma radiation in matter is much higher than that of beta radiation. The mechanism of gamma radiation absorption is also different from that of beta radiation. Low energy gamma rays are absorbed mainly by photoelectric effect observed with visible and ultraviolet light on metals of low work functions. At higher energies scattering of gamma radiation accurs with a reduction in energy and deflection in direction. This scattering gives rise to the Compton Effect, which describes the appearance of a broadly peaked distribution of gamma radiation when a beam of monoenergetic gamma radiation passes through matter.

Practical applications of gamma radiation are based chiefly on its penetrating power. Radiography is one of the more common uses of gamma sources, particularly where extremely high flux is not required. The small physical size of gamma sources is highly advantageous for radiographing areas not readily accessible to x-ray tubes, such as pipe welds, boilers and similar "inside-out" situations. Its penetrating power makes it useful for most tracing applications and ionization sources where ionization must be effected from outside the envelope or uniformly distributed in a large volume.

Most interactions between radiation and matter discussed above involve low level radiation applications which do not cause significant permanent changes in the properties of materials. High levels of radiation can cause profound changes in material properties. In general, changes in properties of organic materials, such as elastomers, plastics, insulation, lubricants and coatings are in the direction of damage. In a few cases, radiation treatment of materials can induce useful and beneficial changes. Design of electromechanical components for service under radiation conditions will be discussed more specifically in a subsequent issue.

MANAGEMENT



STAFF COLUMNIST

Renato Contini

Renato Contini is Research Coordinator at New York University's College of Engineering.

HUMAN ENGINEERING:

Measures and Fallacies

As we become aware of the benefits to be obtained from human engineering studies, it is natural to extend techniques into more difficult areas. Inevitably the techniques and concepts are tried in quite impossible situations, with results approaching the grotesque.

An early example of such consequences is the famous Hawthorne experiment. Here, work performance versus factory environment were the presumed variables. Traditional industrial engineering techniques comprised the measures. It was learned (as expected) that output increased markedly with improvement in surroundings. It was further learned that output also increased with a *deterioration* in environment. Of course the workers were not responding simply to the presumed variable of environment; they were greatly affected by the attention received in the course of the experiments. The attention resulted in strong motivation, which in turn swamped whatever true effect was created by environment.

"Yes, yes", we say, "but that was a long time ago; surely we have learned to handle motivation properly by now."

Advances have been made. The Greek Square system of experimental design and all the statistical techniques of the experimental psychologists have helped greatly. However, the problem is still with us.

About a year ago a "space man" test was arranged by the Air Force in which a man was placed in a capsule for a week. It was reported that the subject stood the confinement well and was able to perform simple tasks readily. Panic and anxiety were presumably absent. This is all very well, but what about motivation? Why should the subject panic when he knows that help is immediately available? In what way does this experiment duplicate the true loneliness of space—where any mistake in action will lead to a solitary death?

Admittedly, the example chosen is extreme, but it does underscore the care which must be taken in dealing with the problem of motivation, and the fact that we are not handling it well.

Mental state is but one factor that is frequently mishandled. Others are the physiological measures and techniques themselves. Consider pulse rate. We all know that our heart beats more quickly after muscular exertion and it seems reasonable to use the increase in pulse rate as a measure of the work performed. Such testing has a long history, including many experimental proofs of a simple correlation between pulse rate and work.

Yet we have conducted tests wherein individuals doing hard physical work (hammering with a standard claw hammer at a rate of 60 strokes per minute for 10 minutes) have actually experienced a *drop* in pulse rate. Such individuals, in top physical condition, seem to regard this arduous task as a "warm up" and grow more relaxed as the work goes on. One wonders whether pulse rate testing is in reality more a measure of the subject's physical fitness than of the task at hand.

What is needed is greater concentration on test techniques and methods, even at the expense of present day results. For if the techniques are suspect, and certainly many are, little is to be achieved by continuing application.

It is time to re-evaluate our techniques.

WORTH FILING

Dual Power Supply

12-page monograph tells all about Philbrick's Model SR-400 Tracking Type Super-Regulated Dual Power Supply. The inside story of the unit is told by a circuit diagram complemented by photographs with "call-out" legends for each circuit component. A 2-page "Trouble Shooting Guide" and boxed notes on crucial points are also included in this brochure.

Source: George A. Philbrick Researches, Inc.
Boston, Mass.
For Your Copy: Circle No. 232 on Inquiry Card

Synchronous Motors

Electric Indicator Company, Inc., manufacturers of instrument-type motors and generators has just published a completely-revised edition of their catalog #EI-4 on Elinco Synchronous Motors. Giving particular emphasis to hysteresis motors, catalog has data on over 200 representative Elinco synchronous motor designs, many of them recently developed. In addition, technical information on the theory and application of all types of synchronous motors is provided for general reference.

Source: Electric Indicator Co., Inc.
Stamford, Conn.
For Your Copy: Circle No. 234 on Inquiry Card

All About Slip-Sticks

24-page booklet, titled "Slide Rule? May I help . . . ", tells how to select a rule. Describes slide rule scale designs and arrangements, materials used in rule construction, and teaching aids and accessories for the slide rule.

Source: Keuffel & Esser Co.
Hoboken, N. J.
For Your Copy: Circle No. 229 on Inquiry Card

Process Instruments Catalog

52-page catalog of process instruments covers indicators, transmitters, recorders and controllers for flow, pressure, temperature, density, viscosity and consistency. In addition, much attention is given to ordering procedures.

Source: Fischer & Porter Co.
Hatboro, Penna.
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A-C Transfer Voltammeter

An instrument that measures alternating voltages and currents in the frequency range 20 to 20,000 cycles per second with an accuracy of plus-or-minus 0.05 percent is being produced in quantity by Charles Engelhard, Inc. Based on a principle disclosed by Francis L. Hermack of the National Bureau of Standards, the new instrument is a commercial a-c voltmeter on which NBS will issue a certificate. Charles Engelhard, Inc. East Newark, New Jersey.
Circle No. 189 on Inquiry Card

MANAGEMENT

STAFF COLUMNIST

Herbert F. Spirer

Assistant Chief Engineer
CGS Laboratories, Inc.
Stamford, Conn.

U-DRIVE-IT-ENGINEERS

In the November '58 issue, I outlined the general nature of job-shopping, a mode of engineering employment that is spreading. This column considers some of the factors that can enter into an engineer's choice of employment mode.

What reasons could an engineer have for preferring job-shopping to captivity? The number of reasons is easily as great as the number of such engineers. Motivation is complex; detailed analysis of the subject is a continuing problem for psychologists. However, some common factors in the choice of job-shopping can be isolated.

ADVANTAGES

More Money. "Top dollars for engineers." A headline almost identical to this was run for over a year whenever an eastern job shop advertised for engineers. It brought results even in the tightest recruiting periods.

On the job, more money can mean a formal recognition of ability and utility. High pay is believed by many engineers to guarantee they will not be put on routine jobs and that adequate supporting personnel and equipment will be provided. When the pay approaches salaries paid to management, considerable prestige is obtained.

Off the job, more money means higher social level, independence, freedom to take extended vacations, economic security and buying power.

Money, therefore, for many job shoppers is one of the most important motives. A typical electronic design engineer with five years experience since school can make about $5.50 to $6.00 per hour plus about $7.00 per day "per diem allowance" or traveling expenses (out of town, and not in N.Y.C.). For overtime, he receives something more than straight time and may even be guaranteed a minimum of overtime. In comparison, the same engineer, as a captive, would make about $4.00 to $5.25 per hour, often without payment for overtime. The difference in net compensation is not trivial.

More Variety. Variety of assignments is the lure for many. A term of job-shop employment may go two years, or as little as six months. With an average assignment lasting less than 1 yr., frequent changes of field are likely, eliminating danger of excessive specialization and providing opportunities to learn techniques in many fields. Most job shop engineers have varied backgrounds and offer an employer many skills. Many find changes in field make design work more challenging.

More Opportunity for Handicapped. Many large companies have medical policies that prevent captive employment of an engineer with serious physical defects, especially those that may eventually cause protracted periods of hospitalization. However, as a job-shopper, paid only for actual time worked, the handicapped engineer is less subject to these medical restrictions. Similarly, age may be a restrictive factor that discourages permanent employment, influencing choice of hourly employment.

More Engineering. The nuisance of administrative aspects of supervision can be avoided by the job-shopper. Generally, a project engineer collects a remarkable amount of non-technical engineering duties: progress reports, estimates, salary reviews, expenditure approvals, space problems, interviewing, service or inter-departmental problems, human relations problems. Job shop engineers rarely get supervisory responsibility or administrative details of this sort. The captive engineer works for the company and is expected to perform a great many non-technical functions. The job shop engineer works for the job. If asked to perform administrative functions, he may start looking for a new assignment without jeopardizing his status.

An aspect of this feeling of loyalty to the job, rather than to the company, is a feeling of professional super-identity. The job shop engineer often feels he is a truly professional engineer. He is selling not his time, or loyalty, but his services. Hired to perform a specific engineering task requiring talent, education, skill and experience, he is expected to provide the best possible engineering solution to a problem. For many engineers, this professional super-identity yields more satisfaction than being a part of a company.

More Company Contacts. Some job shop engineers believe they improve their future standing by the contacts and reputation they make through many job shop assignments. In five years, they will have had three to six assignments, establishing their capabilities with a number of companies or departments likely to be hiring for select jobs in the future.

More Freedom. Control of periods of employment is sometimes a motive. A job shop engineer may take a six week vacation, without changing the nature of his employment, interfering with seniority or arousing any resentment among fellow employees. Also, he can generally arrange to take it when he wants, without loss of standing.

How can any engineer resist these blandishments? The majority of design engineers find it quite easy when they review the disadvantages of job shop employment.

DISADVANTAGES

Frequent Moving. Most changes of assignment for job shop engineers mean changes of location. Dayton last year, Utica this year, Long Island next is a schedule that can make family life very difficult. Most wives don't care for this type of guaranteed, continual transiency, and single engineers may find it difficult to establish satisfactory social life on an intermittent basis. A two year assignment in one area, or one within commuting distance of the engineer's home, is still considered a prize plum and quite rare. This factor, impermanence of location, is by itself sufficient to rule out job-shopping for most engineers.

Less Security. Certain basic types of security are lacking for job shoppers. The captive engineer who is doing well is rarely dropped on one week's notice. If his work is unsatisfactory he is generally given ample warning. In event of cutbacks, most companies attempt to shift personnel and assignments to lengthen employment. In contrast, a job-shopper may be doing well and still be dropped on a week's notice. This can happen shortly after he has made commitments for living quarters, etc. Such short notice may mean undesired time without employment.

Sick leave policies for permanent engineers are quite liberal today. Suddenly disabled, the captive may be supported at full salary for weeks and knows that he is likely "to be taken care of" in an emergency. Job-shoppers get no such general assurance.

Less Communication. Absence of belonging is often lacking for the job shop engineer. He is not part of a company, to whose welfare he contributes, but is an hourly worker putting in time. Long term goals of the company, even the project, may not be communicated to him.

Less Influence. Project responsibility is not often given the job shopper and, after many years, he may still be carrying out plans of younger, less experienced engineers. Because of his status, the job shop engineer may find that he has less influence on planning and company policy than captives have.

These factors may prevent him from growing and learning in project supervision, and consequently, management. Limited to small specific tasks, he may never develop skill in dealing with external and internal services, getting large jobs done with aid of other people, financial and timing problems. And if he has these abilities, he may never get a chance to use them.

Less Long-Term Developments. For many an engineer, with originality and strong creative drive, job-shopping may be frustrating. He is not likely, as a job-shopper, to have an opportunity to follow an original idea to its logical conclusion. The larger the scope and more original the idea the less chance he will have of carrying it from conception to delivery. Companies do not generally look to job-shoppers for next year's products, nor are they likely to entrust a long term development to the guidance of such personnel.

Which kind of employment will an engineer choose? The choice is entirely his. I have pointed out some important factors in such a decision not because there is a widespread trend towards job-shopping—there is not—but because more are job-shopping this year than last.

Maxitorq Electric Clutches and Brakes

A new series of flux-through, disc-type electric clutches with stationary coils covers a range of sizes from ¾ inch bore to 3½ inch bore and up to 2400 lb ft of torque (static).

Incorporating the well proven design principles of Maxitorq floating disc units, the new series combines a specially developed disc assembly design with a new type of electro-magnetic operating mechanism by means of which the clutch (or brake) is held in engaged position by the action of magnetic flux passing through buttress plate, disc assembly and end plate. Upon release, Maxitorq Disc separators not only separate the disc individually, but also break up residual magnetism assuring a positive "floating" neutral which will not creep, drag or heat.

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A new type of Maxitorq Power-Pac, developed for use with these clutches is said to provide extremely fast action, whether by manual, push button or automatic controls and to permit continuous, fast repetition on automatic cycles. A variable transformer or rheostat can change clutch torque carrying capacity by varying the voltage. Standard operating voltage is 90 volts d-c at low wattage; other voltages are available to order. The Carlyle Johnson Machine Co., Manchester, Conn.

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Creativity itself-

High reader reaction to Dr. Maslow's article, "Emotional Blocks to Creativity," in our January-February 1958 issue prompted us to invite him to join us as a Staff Columnist. His current series (this column is part 1 of 2 parts) is based on a talk presented at Symposia on Creativity at Michigan State University. Papers presented at this meeting will be put into book form under the editorship of Harold H. Anderson, Research Professor of Psychology and published by Harper and Brothers. More information on this publication entitled, Creativity and its Cultivation, *can be had by circling no. 55 on the inquiry card.*

first had to change my ideas about creativity about fifteen years ago when I began studying people who were positively healthy, highly evolved and matured, self-actualizing. These ideas have been evolving ever since, and will, I suppose, continue to change. This is, therefore, a report of progress which should be of interest, not only because of the specific subject under discussion, but also because side by side with it has gone a change in my conception of what psychology is and should be.

Very early I had to give up my stereotyped notion that health, genius, talent and productivity were synonymous. A large proportion of my subjects, though healthy, and creative in a special sense that I am going to describe, were *not* productive in the ordinary sense, nor did they have great talent or genius, nor were they poets, composers, inventors, artists or creative intellectuals. And it was obvious that some of the greatest talents of mankind were certainly not psychologically healthy people—Wagner, for example, or Van Gogh or Degas or Byron. So, I had to come to the conclusion not only that great talent was more or less independent of goodness or health of character but also that we know very little about it. For instance, Sheinfeld, in *The New You and Heredity* (Lippincott, 1950), disclosed some evidence indicating that great musical talent and mathematical talent are more inherited than acquired. It seemed clear then that health and special talent were separate variables, perhaps only slightly correlated, perhaps not. And at this time, we may as well admit that psychology knows very little about special talent of the genius type. I shall say nothing more about it, confining myself instead to that more widespread kind of creativeness which is the universal heritage of every human being, and which covaries with psychological health. Furthermore, I soon discovered that I had, like most other people, been thinking of creativeness in terms of products and had unconsciously confined creativeness to certain conventional areas of human endeavor. That is, I unconsciously assumed that *any* painter was leading a creative life, *any* poet, *any* composer. Theorists, artists, scientists, inventors, writers could be creative.

by Dr. A. H. Maslow

ty in Self-Actualizing People

Nobody else could be. You were in or you were out, all or none, as if creativeness was solely the prerogative of certain professions.

But these expectations were broken up by various of my subjects. For instance, one woman, uneducated, poor, a full-time housewife and mother, did none of these conventionally creative things and yet was a marvellous cook, mother, wife and homemaker. With little money, her home was somehow always beautiful. She was a perfect hostess. Her meals were banquets. Her taste in linens, silver, glass, crockery and furniture was impeccable. She was in all these areas original, novel, ingenious, unexpected, inventive. I just *had* to call her creative. I learned from her and others like her to think that a first-rate soup is more creative than a second-rate painting, and that, generally, cooking or parenthood or making a home could be creative while poetry need not be; it could be uncreative.

Another of my subjects devoted herself to what had best be called social service in the broadest sense—bandaging up wounds, helping the downtrodden, not only in a personal way but in an organizational way as well. One of her "creations" is an organization which helps many more people than she could individually.

Another was a psychiatrist, a "pure" clinician who never wrote anything or created any theories or researches but who delighted in his everyday job of helping others to create. This man approached each patient as if he were the only one in the world, without jargon, expectations or presuppositions, with innocence and naïvete and yet with great wisdom, in a Taoistic fashion. Each patient was a unique human being and therefore a completely new problem to be understood and solved in a completely novel way. His great success even with very difficult cases validated his "creative" (rather than stereotyped or orthodox) way of doing things. From another man I learned that constructing a business organization could be a creative activity. From a young athlete, I learned that a perfect tackle could be as esthetic as a sonnet and could be approached in the same creative spirit. In other words, I learned to apply the word "creative" (and also the word "esthetic") not only to products but also to people in a characterological way, and to activities, processes, and attitudes. Furthermore, I came to apply the word "creative" to many products other than the standard and conventionally accepted poems, theories, novels, experiments or paintings to which I had hitherto restricted the word.

The consequence was that I found it necessary to distinguish "special talent creativeness" from "self-actualizing creativeness" which sprang much more directly from the personality, which showed itself widely in the ordinary affairs of life, and which showed itself not only in great and obvious products, but also in many other ways—in a certain kind of humor, in a tendency to do *anything* creatively; e.g., teaching, etc. Very frequently, it appeared that an essential aspect of creativeness SA was a special kind of perceptiveness that is exemplified by the child in the fable who saw that the king had no clothes on. (This too contradicts the notion of creativity as products). These people can see the fresh, the raw, the concrete, the ideographic, as well as the generic, the abstract, the rubricized, the categorized and classified. Consequently, they live far more in the real world of nature than in the verbalized world of concepts, abstractions, expectations, beliefs and stereotypes that most people confuse with the real world. This is well expressed in Rogers' phrase "openness to experience".

All my subjects were relatively more spontaneous and expressive than average. They were able to be more "natural" and less controlled and inhibited in their behavior which seemed to be able to flow out more easily and freely and with less blocking and self-criticism. This ability to express ideas and impulses without strangulation and without fear of ridicule from others turned out to be a very essential aspect of creativeness SA. Rogers has used the excellent phrase, "fully functioning person," to describe this aspect of health.

Another observation was that creativeness SA was in many respects like the creativeness of *all* happy and secure children. It was spontaneous, effortless, innocent, easy, a kind of freedom from stereotypes and clichés. And again it seemed to be made up largely of "innocent" freedom of perception, and "innocent," uninhibited spontaneity and expressiveness. Almost any child can perceive more freely, without *a priori* expectations about what ought to be there or what must be there or what has always been there. And

continued —►

Abraham H. Maslow, Professor of Psychology and Chairman of the Department, Brandeis University, formerly taught at University of Wisconsin and Brooklyn College. He is on the Board of Editors of PERSONALITY SYMPOSIA *and* SOCIAL PROBLEMS. *In addition, he is co-author of* PRINCIPLES OF ABNORMAL PSYCHOLOGY; *his most recent book is* MOTIVATION AND PERSONALITY. *As a member of the American Psychological Association, he was elected a fellow in the Association's Division of Abnormal and Clinical Psychology and President of the Division of Personality and Social Psychology. He is, also, a member, Board of Directors, Society for the Psychological Study of Social Issues.*

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almost any child can compose a song or a poem or a dance or a painting or a play or a game on the spur of the moment, without planning or previous intent.

It was in this sense that the creativity of my subjects was childlike. These traits, however, certainly differed in quality from what is found in children. If children are naive, then my subjects had attained a "second naïvete" as Santayana called it. Their innocence of perception and expressiveness was combined with sophisticated minds.

In any case, this all sounds as if we are dealing with a fundamental characteristic, inherent in human nature, a potentiality given to all or most human beings at birth, which often is lost, buried or inhibited with enculturation.

My subjects were different from the average person in another characteristic that makes creativity more likely. SA people are relatively unfrightened by the unknown, the mysterious, the puzzling, and often are positively attracted by it; i.e., selectively pick it out to puzzle over, to meditate on and to be absorbed with. I quote from my description in *Motivation and Personality* (Harpers '54): "They do not neglect the unknown, or deny it, or run away from it, or try to make believe it is really known, nor do they organize, dichotomize, or rubricize it prematurely. They do not cling to the familiar, nor is their quest for the truth a catastrophic need for certainty, safety, definiteness, and order, such as we see in an exaggerated form in Goldstein's brain-injured or in the compulsive-obsessive neurotic. They can be, when the total objective situation calls for it, comfortably disorderly, sloppy, anarchic, chaotic, vague, doubtful, uncertain, indefinite, approximate, inexact, or inaccurate (all, at certain moments in science, art, or life in general, quite desirable).

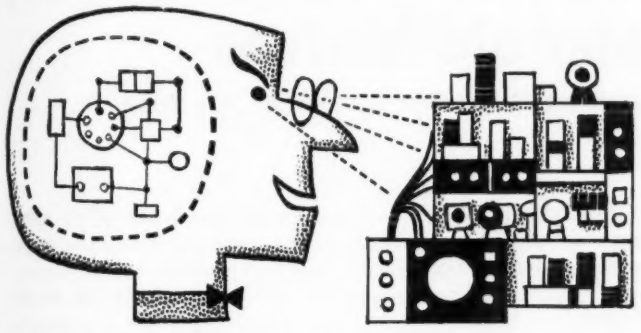
"Thus it comes about that doubt, tentativeness, uncertainty, with the consequent necessity for abeyance of decision, which is for most a torture, can be for some a pleasantly stimulating challenge, a high spot in life rather than a low."

One observation I made has puzzled me for many years but it begins to fall into place now. It was what I described as the resolution of dichotomies in self-actualizing people. Briefly stated, I found that I had to see differently many oppositions and polarities that all psychologists had taken for granted as straight line continua. For instance, to take the first dichotomy that I had trouble with, I couldn't decide whether my subjects were selfish or unselfish. Observe how spontaneously we fall into an "either/or" here. The more of one, the less of the other is the implication of the style in which I put the question. But I was forced by sheer pressure of fact to give up this Aristotelian style of logic. My subjects were very unselfish in one sense and very selfish in another sense. And the two fused together, not like incompatibles, but rather in a sensible, dynamic unity or synthesis very much like what Fromm has described in his classical paper on Self-Love; i.e., on healthy selfishness. My subjects had put opposites together in such a way as to make me realize that regarding selfishness and unselfishness as contradictory and mutually exclusive is itself characteristic of a lower level of personality development. Similarly, in my subjects, were many other dichotomies resolved into unities; conation vs cognition (heart vs. head, wish vs. fact) became cognition "structured with" conation as instinct and reason came to the same conclusions. Duty became pleasure and pleasure merged with duty. The distinction between work and play became shadowy. How could selfish hedonism be opposed to altruism, when altruism became selfishly pleasurable? These most mature of all people were also strongly childlike. These same people, the strongest egos ever described and the most definitely individual, were also precisely the ones who could be most easily ego-less, self-transcending, and problem-centered.

But this is precisely what the great artist does. He is able to put together clashing colors, forms that fight each other, dissonances of all kinds, into a unity. And this is also what the great theorist does when he puts puzzling and inconsistent facts together so that we can see that they really belong together. And so also for the great statesman, the great therapist, the great philospher, the great parent, the great lover, the great inventor. They are all integrators, able to put separate and even opposite factors together into unity.

We speak here of the ability to integrate—of the play back and forth between integration within the person and his ability to integrate whatever it is he is doing in the world. To the extent that creativeness is constructive, synthesizing, unifying, and integrative, to that extent does it depend in part on the inner integration of the person.

In trying to figure out why all this was so, it seemed to me that much boiled down to the relative absence of fear in my subjects. They were certainly less enculturated; that is, they seemed to be less afraid of what other people would say or demand or laugh at. It was found that they had less need of other people and therefore, depending on them less, could be less afraid of them and less hostile against them. Perhaps more important, however, was their lack of fear of their own insides, of their own impulses, emotions, thoughts. They were more self-accepting than the average. It was this approval and acceptance of their deeper selves



that made it possible for them to perceive bravely the real nature of the world; it also made their behavior more spontaneous (less controlled, less inhibited, less planned, less "willed" and designed). They were less afraid of their own thoughts even when they were "nutty" or silly or crazy. They were less afraid of being laughed at or of being disapproved of. They could let themselves be flooded by emotion. By contrast, average and neurotic people walled off, through fear, much that lay within themselves. They controlled, they inhibited, they repressed and they suppressed. They disapproved of their deeper selves and expected that others did, too.

What I am saying in effect is that the creativity of my subjects seemed to be an epiphenomenon of their greater wholeness and integration, which is what self-acceptance implies. The civil war within the average person between the forces of the inner depths and the forces of defense and control seems to have been resolved in my subjects and they are less split. As a consequence, more of themselves is available for use, for enjoyment and for creative purposes. They waste less of their time and energy protecting themselves against themselves.

Part 2 of Dr. Maslow's "Creativity in Self-Actualizing People" discusses the phenomenon he calls "peak-experience" and its relevance to an understanding of creativity. He covers the different roles of the "primary" (non-rational) and the "secondary" (rational) processes in creativity preparative to his discrimination between primary, secondary and integrated creativeness.

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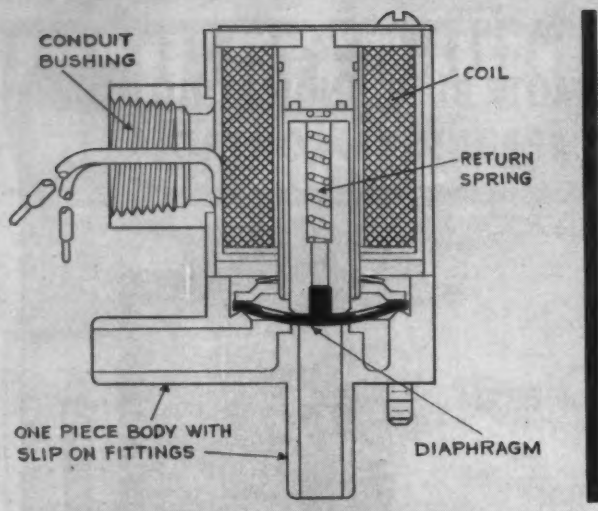


Fig 1—Normally closed, diaphragm shut-off valve

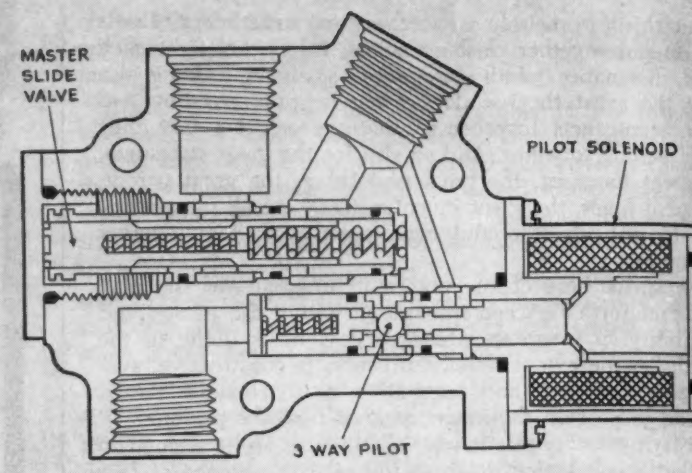


Fig 2—Three-way pilot operated valve

How To Specify Solenoid Valves

George F. Kelly • *Project Engineer* • *Valcor Engineering Corporation, Kenilworth, New Jersey*

Furnishing a design engineer with the best possible solenoid valve for his application can present severe difficulties to a valve manufacturer. The major reason for such difficulties normally result from an insufficient and incomplete specification of what the valve must do with what media under what conditions and for how long. Overlooking any one factor can result in either proposing a valve which more than meets the requirements of the application or on the other hand does not meet some of them with—in both cases—consequent losses of efficiency, time and money. Thousands of valves can be shipped before it becomes apparent that the valve was over-specified or fails to meet a tight specification.

This article is a check list of electrical and mechanical application requirements that affect a valve manufacturer's proposals and recommendations for a specific design. If you follow it carefully, 95 percent of all your solenoid valve applications will be properly and completely specified—and you will obtain the best valve for your application at a minimum cost. The 5% of the applications it will not cover will become apparent to you as you follow the check list. These special cases require even greater care and you should thoroughly discuss these with the manufacturer's representatives, in many cases before stabilizing on design details of your system. Here then is the check list.

Solenoid Valve Nomenclature

SOLENOID VALVE TYPES

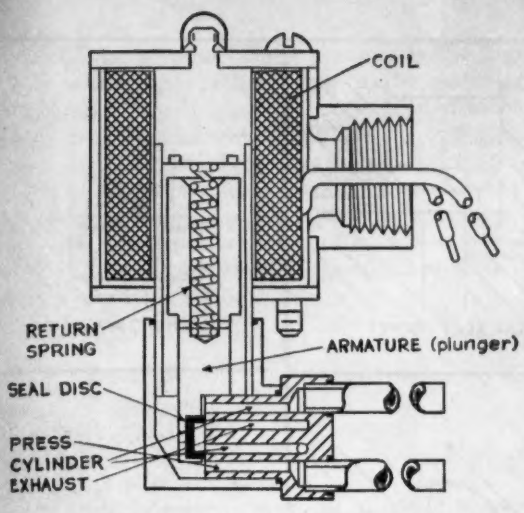
When valve types are specified as two-way (shut-off), three-way, four-way, or five-way, the digit always refers to the number of ports. Two-way valves must be specified as normally opened or closed. Valving operation utilizing more than 2 ports (three-way, four-way) must be described in words or by a schematic to show which ports are interconnected when the solenoid (or solenoids) are energized or de-energized. In this type of valve design the port interconnections are usually specified as the number of positions. For example, a four-way valve with two solenoids could be a two or three position valve connecting two or three ports. On high pressure or high flow valves, check your system design to determine whether pilot operation is permissible. "Pilot operation" is useful when you do not have sufficient power to actuate a large valve; a smaller "pilot valve" is first actuated admitting fluid for the actuation of the larger valve. Figure 1-4 illustrate these designs.

Note all special features and characteristics of your system that control valve characteristics such as non-interflow in multiple port valves, free flow in reverse direction, metering, manual override, built-in relief, position indicators; the relationship of these factors to the main valve functions should be described. If you want to incorporate several valves in a common assembly, you can specify them separately noting in each specification that they are to be integrated into one assembly.

VALVE SEATS

Normally, valve seating is not of interest to the valve user whose primary consideration is meeting the functional requirements of his design with proper valving at minimum cost. However, type of seating is sometimes specified by a design engineer, based on past experience which has proven one type of seating better than another because of factors germaine to the specific design; contaminants in the fluid, servicing, fail safeness or other environmental problems peculiar to a particular industry. Fig. 5 illustrates types of seatings generally available in small and medium sized solenoid valves.

• Poppet: An axial lift valve in which a conical surface



3—Four-way floating seal valve (Valcor Engineering ...p. patent)

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seats on a matching cone or a sharp edge. These valves are generally recommended by manufacturers for different services that utilize a large open area or a short solenoid lift combined with high seating pressure.

- Flat: an axial lift valve in which a flat seats on a flat. These valves, widely used, have a maximum open area for a minimum solenoid lift.
- Diaphragm: an axial lift valve in which a flexible diaphragm or bellows seats on or over a passage. These valves are used in low pressure service eliminating stem seals and at the same time isolating the solenoid from the pressurized fluid.
- Slide: an axial lift valve that relies on the fit of a cylinder in a bore for sealing effects. Slide valves are the most common types of valves in oil hydraulic systems for aircraft and industrial applications. It offers short stroke, minimum friction and force for actuation and can be designed for very complicated functions such as the sequencing of power circuits. Its disadvantages: leakage must be permissible and since leakage is determined by the closeness of fit, these valves will not tolerate contaminants; they are also expensive when small leakages are mandatory.
- Rotary: a valve that depends on rotary elements such as balls with a hole through them or a rotatable flat plate. Rotary valves are generally used in larger sized valve designs and are more apt to be motor driven because of the large stroke. Force required is low and cost is low; however, some leakage must be allowable.
- Shear Seal: an axial lift valve that depends on the mating of two surfaces parallel to the lift for sealing. Only a few companies manufacture a shear seal type of valve. While the stroke is comparatively long, the valve has the advantage of straight-through flow with a consquent ideal flow characteristic and wiping action which makes the valve highly resistant to contaminants. Since leakage depends on trueness of flat on flat, a small leakage must be

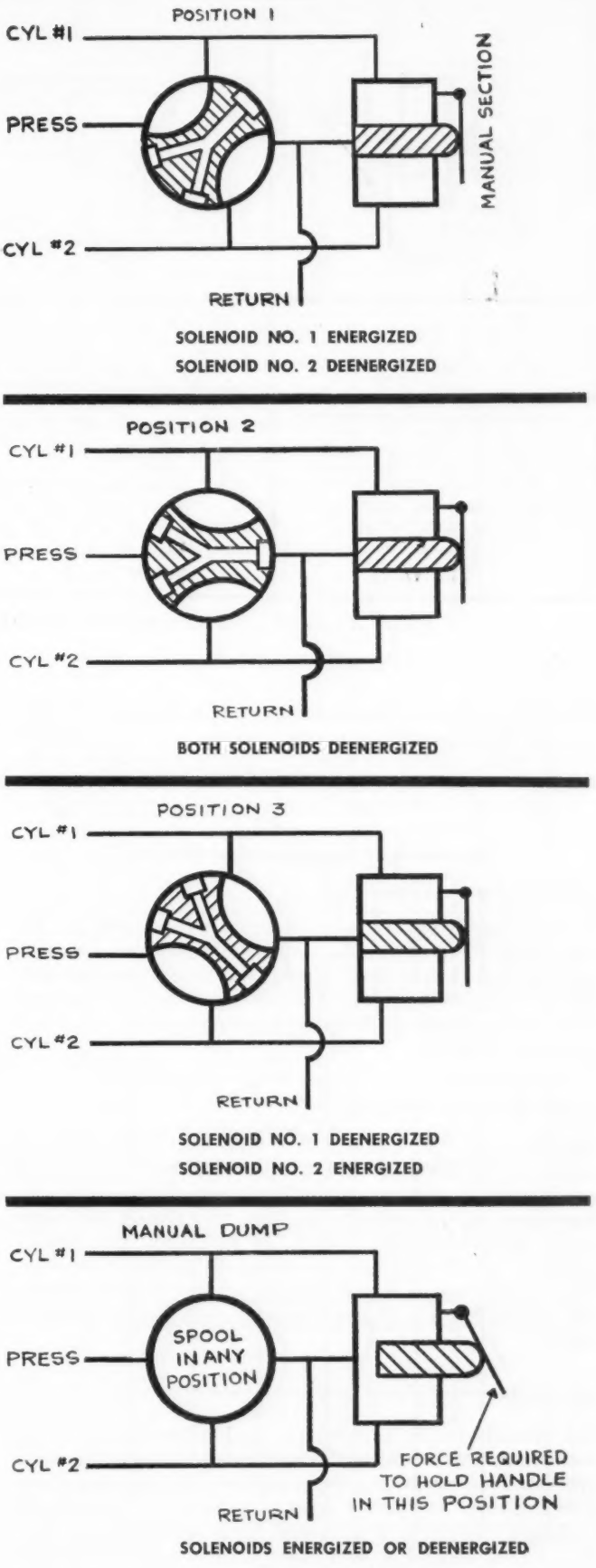

Fig 4—Valve schematic illustrates how diagrams simplify and clarify inter-related functional requirements and should be included with and instead of a written description. Valve is a four-way, three position, manual dump valve.

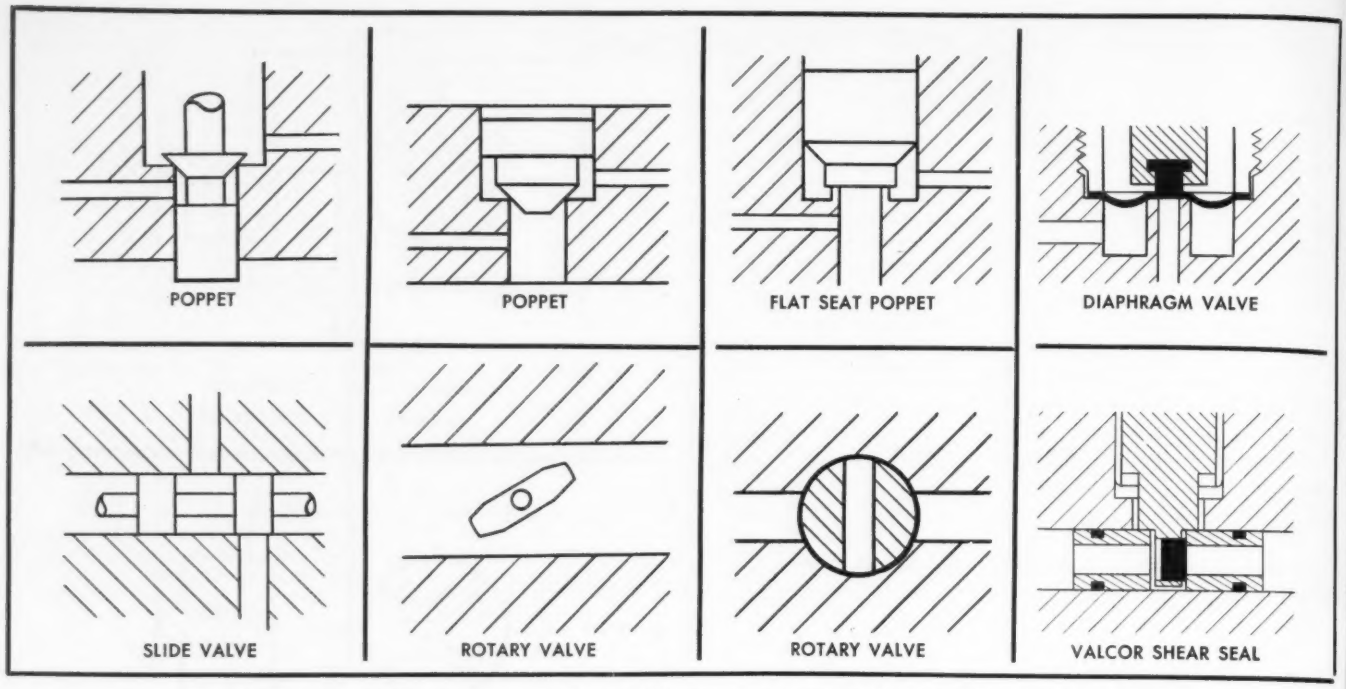

Fig 5—Types of valve seats generally available in small and medium sized solenoid valves.

allowed particularly in gas service for reasons of economical manufacture. However, unlike more conventional types, leakage tends to decrease with life because of the tendency of the seal disc and seat to lap into each other.

Mechanical Specification Criteria

APPLICATION DESCRIPTION

A brief description of your design application helps the valve manufacturer to draw on his wide experience to suggest the most satisfactory valve at the lowest possible cost. He may suggest system modifications and/or multi-purpose components that result in better functioning, lower cost and less parts (Fig 6).

FLUID CHARACTERISTICS

Impurities or solid particles in a fluid affect valve life and operation. If the fluid is unusual or highly corrosive and you know from experience what materials have resisted this fluid most satisfactorily in the past, you should call them to the manufacturers attention. In any event you should precisely specify the fluid including all pertinent information; for instance, if a steel pickling solution is to be valved, you should specify all the chemicals and their concentrations.

PRESSURE

You should specify a maximum and minimum operating pressure and a back pressure under which the valve must operate. This condition may be different for energizing and de-energizing. In piloted types of valves, it is particularly important to specify a minimum actuating pressure, since these valves depend on some line pressure to provide power adequate for functioning. In addition to operating pressures, you must specify maximum line pressure and a proof and burst pressure. Proof pressure is the maximum pressure which the valve will sustain without any of the parts undergoing a permanent set or deformation. In other words, all parts will return to their original size and shape upon

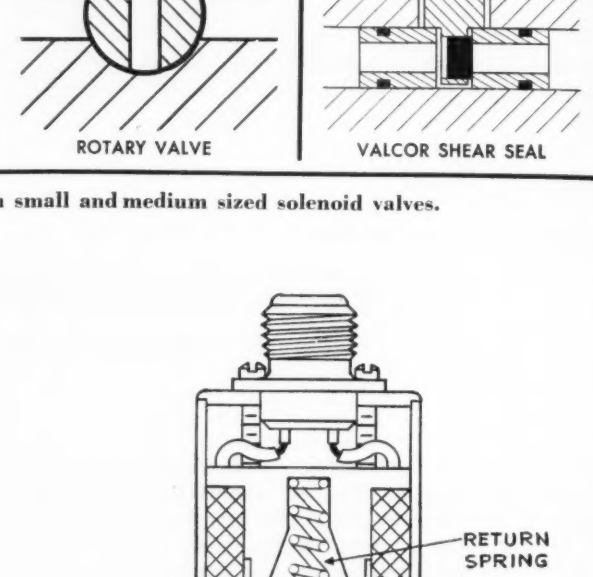

Fig. 6—In an engine starter application, combining two valves resulted in the elimination of one solenoid and insured the simultaneous action of both valves. Design prevents danger of fire that could occur if one fluid circuit was opened and the other remained closed.

release of the pressure. Burst pressure is the highest pressure to which a production valve can be subjected without structural failure. If you do not specify proof and burst pressures, the manufacturer will use his own standards. In general practice, proof pressures are at least one and one-half times the maximum line pressure and burst pressure is generally two to four times the line pressure. Although proof and burst pressures are often not specified for low pressure valves, they always should be specified for high pressure valves.

VALVE CAPACITY

You should specify the desired capacity—flow vs pressure drop—for each flow path in the valve. You can specify capacity in one of three ways:

- Maximum allowable pressure drop at a given flow. Pressure drop is usually specified in pounds per square inch but may be given in other convenient units such as inches of mercury or feet of water. Flow is usually specified as gallons per minute; pounds per second, minutes or hours; or cubic feet per minute. You can determine pressure drop either from your process requirement—the amount of fluid to be delivered in a unit of time—for instance, 6 ounces of Coca-Cola in six seconds in a vending machine application, or from the work requirement—the amount of fluid required to operate a fluid motor cylinder—for instance 120 cubic inches a minute for a cylinder with two cubic inch displacement operating sixty times a minute.

Pressure drop through the valve at rated flow is a measure of valve efficiency. Design engineers naturally like to have zero pressure drop; however, zero pressure drop leads to large envelopes, large solenoids with high current drain and high cost. Consequently, although an essentially zero pressure drop—no larger than in a length of line equal to valve length—can be obtained in straight-through types of valves such as Valcor shear seal valves, it is to your advantage to allow as much pressure drop as possible. An allowable pressure drop of 1 to 5 percent of the upstream pressure minimizes valve cost.

- You can specify pressure drop by determining the minimum pressure available at the power source and the allowable minimum pressure required at the discharge or power use point. Then determine from the system or, on the other hand, design the system such that the difference in the above two pressures is not exceeded by the summation of the pressure drops in the lines including all components between the pressure source and the point of use. From this analysis you can determine or set the maximum permissible pressure drop at rated flow for each component (See Figs. 7 and 8).

When specifying gas flow from Fig. 8, the parameter $\sigma \Delta P$ in psi is defined as:

$$\sigma = [(P_x + P_y)/2]\,[1/P_o]\,[T_o/T_x]$$

$$\Delta P = P_x - P_y$$

$$\sigma \Delta P = 17.6\,(P_x^2 - P_y^2)/T_x$$

Where P_x is the upstream pressure (psia)

P_y is the downstream pressure (psia)

$P_o = 14.7$, standard atmospheric pressure (psi)

$T_o = (460 + 60F) = 520R$ corresponding to 60F

T_x = the upstream absolute temperature in degrees Rankine or $(460 + °F)$

$\Delta P = P_x - P_y$ the pressure drop in psi

$\sigma \Delta P$ is a valid parameter for universal use because the mass flow of a gas through a nozzle or orifice is directly related to the square root of the gas density and the pressure drop. The "σ" term basically corrects the pressure drop at the actual conditions to the pressure drop that would occur if the gas density was the density at standard conditions. This assumption is valid for any gas which reason-

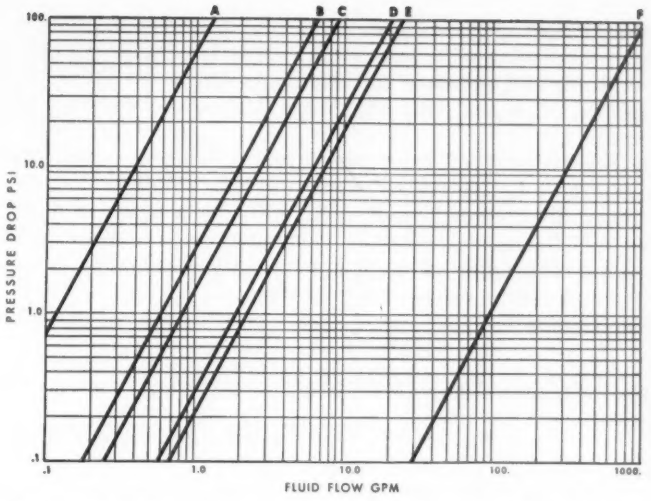

Fig 7—Manufacturers normally illustrate the flow characteristics of their valves by plotting pressure drop in psi vs fluid flow in gallons per minute. Note that on a logarithmic plot all curves for liquids are straight lines of equal slopes; thus finding one point establishes the curve.

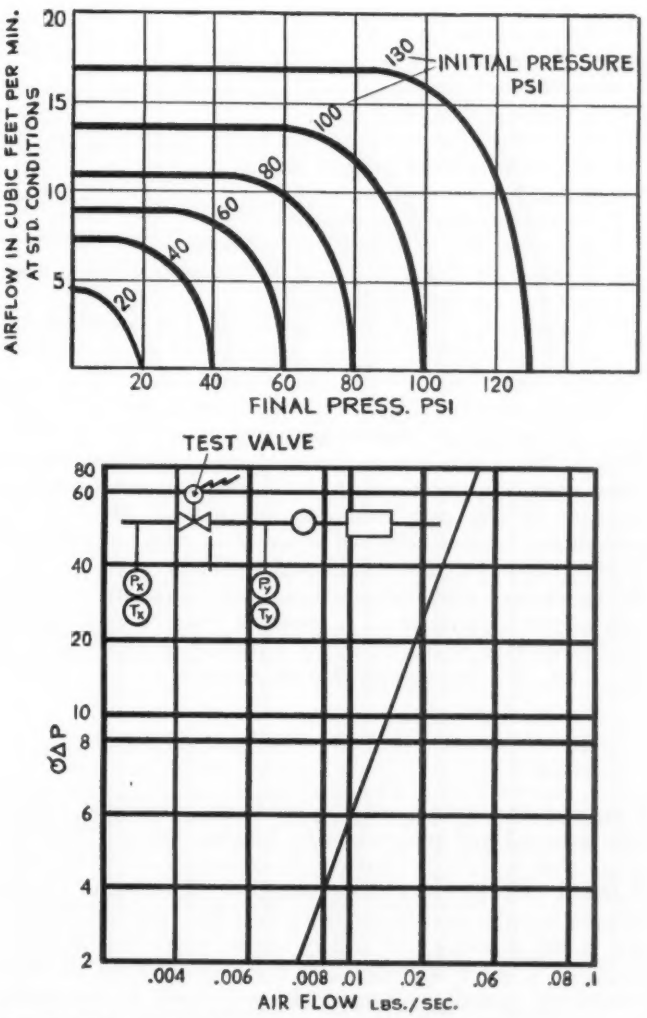

Fig 8—Two methods can be used to specify flow characteristics of gases. When air flow is plotted against final pressure, the families of curves show how the specific volume of the gas varies with pressure and temperature. $\sigma \triangle P$ vs flow for a gas allows comparison of tests run at different temperature and pressure conditions.

ably follows ideal gas laws. It has the advantage of simpleness, and allows the comparison of tests at different temperatures and pressure conditions. As far as we know this method originated with the North American Aviation Corporation.

• Specification of valve size by specifying a valve flow coefficient, C_v, is widely used and may in time become universally accepted practice. C_v provides a figure of merit by which one valve can be compared with another at a glance. The figure of merit appears in the following equation and can be calculated from them.

For liquids

$$GPM = C_v(\Delta P/G)^{1/2}$$

For Gas, critical flow, $\Delta P > \frac{1}{2}P_x$

$$Q = 695\, C_v\, P_x/H^{1/2}$$

For Gas, noncritical flow, $\Delta P < \frac{1}{2}P_x$

$$Q = 1360\, C_v\, [(\Delta P\, P_x/H)]^{1/2}$$

For Steam, noncritical flow, $\Delta P < \frac{1}{2}P_x$

$$W = 3\, C_v\, K(\Delta P P_y)^{1/2}$$

For Steam, critical flow, $\Delta P > \frac{1}{2}P_x$

$$W = 1.5\, C_v\, K\, P_x$$

Where

$H = G(460 + F)$
GPM = gallons/min (liquid)
Q = cubic ft/hr at 68F and 14.7 psia (gas)
W = lbs/hr (steam)
P = pressure drop in psi
G = specific gravity (dry air or water = 1)
V = specific volume of inlet steam
P_x = upstream pressure psia
P_y = downstream pressure—psia
F = temperature in degrees Fahrenheit
K = coefficient for steam quality or degree of superheat
= 1 for dry saturated steam
= 1—moisture content in percent (for wet steam)
$= (1 + 0.000655)^{1/2}$ (for superheated steam where S = F superheat)

Thus a valve with a C_v of 1 means that the valve will pass one gallon per minute of water at a 1 psi pressure drop or 598 cubic feet per hour of air at standard conditions with a pressure drop of 1 psi and an upstream pressure of 100 psia and a temperature of 60F; or 30 pounds per hour of saturated steam at an upstream pressure of 100 psia and a pressure drop of 1 psia.

• Equivalent Orifice—Sometimes valve capacity is specified as the equivalent of a standard sharp edged orifice; that is its flow characteristic is equal to or better than a sharp edged orifice of specified diameter.

LEAKAGE

You must specify wherever possible the maximum allowable external and internal valve leakage and the pressure range over which the leakage specifications must be met. External leakage from the interior to the exterior of the valve is usually specified as zero over the range of zero to the proof pressure; in other words, over the pressure range of a valve operation, no bubbles or drops of fluid should be visually detected. If you need requirements better than this, you should specify hermetic sealing for the valve.

Internal leakage, the leakage from port to port when the valve is in the closed position, should be determined realistically from your application requirements. Realistic internal leakage permits the manufacturer to propose the least expensive type of valve, avoiding unnecessary quality control measures at both the manufacturer's and your plant. All too often, internal leakage is specified as zero, an ambiguous statement since with modern instruments leakages can always be detected. A mass spectrometer or very sensitive helium detector can pick up leakages in molecules per second. Ordinarily zero leakage is interpreted by the manufacturer as no bubbles or drops of fluid over a short period of time ranging from seconds to ten minutes. Thus it is better to specify a finite leakage rather than zero; for example: one drop per minute, one cc per ten minutes or one ounce per year.

VALVE LIFE

Minimum number of operating cycles and storage life required should be either specified or at least some idea or estimate of this requirement should be given to the manufacturer.

SPEED OF VALVE OPERATION

When speed of valve operation is important, specify the maximum or minimum time required to move the valve from position to position. If you want this time to be adjustable, note your requirements with the limits you desire. You may specify this requirement by giving the number of cycles per second or minutes. Note that manufacturers interpret the speed of operation in one of two ways. First, the maximum time for the valve to move from one position to the other; second, the maximum time allowed for the flow and pressure conditions on the downstream side to reach the specified values with the upstream condition maintained at either the nominal or worst values. Wherever possible you should select that basis of specification that best suits your needs.

VALVE ENVELOPE

If you have limited space available for the valve or its configuration details such as port locations, electrical connections and other valve characteristics are important, you should call these factors to the manufacturers attention. Make your specifications as liberal as your application allows. If the manufacturer can propose one of his standard or semi-standard models, your cost will usually be appreciable smaller than the cost for a custom tailored design. Remember to specify the desired size and location of ports, provisions for mounting the valve, type, size and location of electrical connections, making these specifications as loose and as liberal as your application allows. Dimensions should have as broad tolerances as are possible and alternate locations of ports should be specified if it is possible so that you can achieve your best design with the lowest possible valve cost.

Electrical Specification Criteria

SOLENOID

Solenoids are usually available for direct current at 6, 12, 24, 50 and 100 volts and for 60 cycles alternating current at 110 and 220 volts. You must specify maximum and minimum voltage at which the valve must operate, including the maximum steady state current or power that can be consumed. The manufacturer needs to know the maximum inrush current available since alternating current solenoids have a large momentary inrush.

Sometimes a two-coil switching design can be used to advantage; this type may draw 20 amperes for 20 to 50

Valcor Engineering Corp.

SOLENOID VALVE

SPECIFICATION CHECK SHEET

Company: ..... Address: .....

Contact: ..... Title: ..... Tel. No.: .....

Application: .....

.....

Job No.: ..... Refer to Dwg. No.: ..... Project No.: .....

MECHANICAL SPECIFICATIONS

Operating Pressure: Max ..... psi, Min ..... psi, Max Line Pressure ..... psi, Proof Pressure ..... psi, Burst Pressure ..... psi,

Allowable Pressure Drop ..... psi at ..... GPM flow. Is Back Pressure Important ..... ? Valve Flow schematic Attached? .....

Flow Requirement ..... GPM; Orifice Equivalent .....; Fluid Temp. ..... °F; Ambient Temp. ..... °F; Fluid Type .....

Chemical Analysis ..... Particle Suspension: Yes ... No ...; Max Particle Size .....

Valve Type: 2 .. 3.. 4.. Way or Diverter .....; Normally Open ....; Closed ....; Port, Pipe or Tubing Connectors .....

Allowable Leakage: External ...., Internal ....; Manual Overide ...., Metering ....., Position Indicators .....

Built-in Relief ....., Free Flow in Reverse ....., Other .....

Valve Seat Preference: Flat .. Diaphragm .. Slide .. Rotary .. Shear Seal .... Other .....; Max Wgt..... Dimensions (if min.) .....

Must Valve Be: Explosion Proof .....? Immersion Proof .....? Is Vibration ..... or Humidity ..... or shock ..... a problem?

ELECTRICAL SPECIFICATIONS

Voltage Available: ..... AC ..... DC ..... Watts .... Amps. Preferred Operating Voltage: ..... AC ..... DC ..... Watts ..... Amps.

Duty Cycle: Continuous ..... Intermittent ..... Max On Time ..... Max Off Time ..... Max No. of Consecutive Cycles .....

Receptacle ....., Conduit ....., Pigtail in Inches ..... Military Specs: ....

Other Specs: JIC ..... AGA ..... ASME ..... Underwriters ..... Other .....

No. of Units Required: Now ..... Yearly .....

Submitted by ..... Title ..... Date .....

milliseconds and then when an internal switch cuts out the large coil, the current draw is reduced to ¼ ampere. Some applications require that you specify a minimum drop out voltage, the voltage at which the solenoid plunger breaks loose from the solenoid stop and moves to the deenergized position.

DUTY

The solenoid should be specified as continuous or intermittent duty. If the solenoid can be maintained energized for more than one hour, it should be specified as continuous duty. If your specifications permit an intermittent duty solenoid, then specify the worst duty cycle; namely, the maximum on time and minimum off time following the maximum on time before reenergizing. Try to use an intermittent duty solenoid where practical since it contains less copper and iron with a corresponding decrease in cost.

ELECTRICAL CONNECTIONS

Electrical connections are varied: on industrial valves pigtail leads through a strain relief, conduit or insulated terminals are commonly supplied; on aircraft military type valves AN type receptacles are normally used. In any event specify the type, size of connection and grounding unless your application is flexible and you can accept the connection preferred by the manufacturer.

COIL CONSTRUCTION

The general valve specification determines the type housing and coil construction in accordance with accepted standards for the application. If you need special requirements such as moisture proof, explosion proof or immersion proof valves, you can specify their construction by requiring conformance to military standards or to industrial standards such as J.I.C., Underwriters, AGA or ASME.

Environmental Specification Criteria

APPLICATION ENVIRONMENT

Fluid temperatures and maximum and minimum ambient temperatures can seriously affect the performance of a

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solenoid valve and should be noted on your specification sheet along with special environmental conditions such as corrosiveness, combustibility of the atmosphere and humidity. Vibration, acceleration and shock should be noted in any application where they may be present to an important degree such as in automotive, aircraft and high speed machinery. Note whether the valve must operate under the specified conditions, or merely withstand them.

TESTING AND TEST SPECIFICATIONS

Misunderstandings resulting in valve rejections can arise because of differences in inspection testing techniques and interpretation of test results. In critical applications, test procedures and techniques should be mutually agreed upon to avoid misunderstandings. And a very good place to specify this is in the original specification, even though it may have to be loose because of the general nature of the specification and the number of design possibilities capable of fulfilling it. Original specifications have the effect of reminding both parties of the importance of mutually agreed upon test procedures and methods before the initiation of any real production.

SAFETY

Special of unusual safety requirements demanded by your application should be specified clearly: interlocks, warning switches, indicators or requiring the valve to remain in its last position or to move to a particular position or condition in the event of current failure.

For every valve all the mechanical, electrical and environmental specification criteria should be considered. For many valves and applications only the barest operating information and a word or two of application description is sufficient; for instance, ¼ NPT, 1000 psi, 110 volt, 60 cycle AC solenoid normally closed shut-off valve for shop compressed air use, will most likely allow a manufacturer to choose a satisfactory valve to offer a customer. The same description for an aircraft application will result in a valve being proposed which is unsatisfactory because of the many conditions which cannot be predicted or anticipated by the manufacturer and which are important factors in arriving at a satisfactory valve design.

Normally the line size, the line pressure, type of valve, fluid media on perhaps several important features or operating characteristics presented in a few words will orient the manufacturer to your needs. But a more simple and more reliable procedure would be to fill out those pertinent sections on the Solenoid Specification Check List appearing with this article and submit it to the manufacturer. In 95 percent of your applications you will save time and permit the manufacturer to use his experience and background in recommending the best valve at the lowest cost.

For your free copy of this article:
Circle No. 68 on Inquiry Card.

WORTH FILING

Data Processing Tool

38-page brochure describes translation capabilities of the basic translator system, system engineering services, sale or lease terms and maintenance service of the Computer Language Translator which provides for rapid, efficient translation between different types of electronic computers and related processing equipment.

Source: Electronic Engineering Company
Santa Ana, California
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For Your 3-Ring Binder

NEW DATA SHEETS

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NEW HALL GENERATOR, used as a circuit element, is essentially a solid-state multiplying device that provides a voltage output proportional to the product of two electrical quantities: the control current passing through it and the magnetic field perpendicular to its major face. It can, therefore, multiply two electrical quantities if one is expressed as current and the other as a magnetic field. Because of its extremely fast response time, the instrument can also be used to measure the power content of transients. Westinghouse Electric Corp., Pittsburgh, Pa. Circle 164.

KNITTED WIRE MESH *application data for heat sinks and tubes, RF shielding and pressure sealing gaskets. Metal Textile Co., Roselle, N. J. Circle* 250.

PRINTED WIRING design criteria are discussed in a new illustrated catalog (E-5). Standardized definitions and military design standards are presented. Includes pictures and descriptions of various electronic components adaptable to printed wiring boards. Rowe Engravers, Paterson 4, N. J. Circle 173.

SHEATHED THERMOCOUPLE WIRE *with ceramic alloy insulation, available in several I.S.A. calibration and in outside diameters from 0.020" to ½" with a wide choice in sheath material and magnesium, aluminum, or zirconium oxide hard-pack insulation, are described, together with various standard junction tips, fittings and connectors. Claud S. Gordon Co., Chicago, Illinois. Circle* 193.

TRANSISTORIZED CONVERTERS, d-c to d-c, designed for incorporation into a wide variety of battery-powered airborne and mobile electronic equipment, provide an economical efficient means of obtaining higher voltages from standard 6-, 12-, or 28-volt d-c sources. Standard output voltages range from 50 volts d-c (30, on 12-volt models) to 1000 volts d-c. Powers to 200 watts in 12v models; to 150 watts in 28v models and to 90 watts in 6v models. Convenient, rugged, packaged construction makes the new QC supplies easy to apply. Sorensen & Co., Inc., South Norwalk, Conn. Circle 174.

SELECTOR GUIDE FOR METAL MELTING *tells how to select cast-in immersion heaters, controls and melting pots for soft-metal melting applications, gives melting data and includes table for determining heater kilowatt-hour requirements for melting solder, tin and lead. Complete product data and pricing information listed for all heating equipment and melting pots. General Electric Co., Schenectady, New York. Circle* 182.

MAGNETIC CIRCUITS sketchbook in latest issue of "Applied Magnetics" presents a summary of permanent magnetic circuits especially suited for tractive applications which utilize the attractive, holding, or repelling forces of permanent magnets. Applied Magnetics, Indiana Steel Products Co., Valparaiso, Indiana. Circle 194.

KERR CELL SHUTTER *for photography at exposures down to 0.01 of a microsecond described with charts, drawings, and photographs. Avco Research and Advanced Development Division, Wilmington, Mass. Circle* 166.

BEAM POWER PENTODE, compact 7-pin miniature, offers high power sensitivity at extremely low plate and screen supply voltages. For example, a peak a-f input voltage of three volts provides 1.4 watts output with supply voltages of only 110-volts, plate, and 115-volts, screen. Heater currents of the four types are 1.2 amperes, 600 ma, 300 ma, and 150 ma, respectively. The 600-ma version is heater warm-up controlled for series strings. CBS-Hytron, Danvers, Mass. Circle 191.

MOTOR-ALTERNATOR SERIES, *designed for all 420 cps output service in the 250VA requirement area, can be used in end equipment or in laboratory or test applications. The new units will operate computers, synchros, servo mechanisms and other types of control equipment. Outputs available are: 115 or 230 volts, single, two or three phase, at 420 cps. Inputs may be supplied at 230 or 460 volts, 50 cps, three phase; 220 or 440 volts, 60 cycles, three phase; or 220 volts, 60 cycles, single phase. Electric Motors and Specialties, Garrett, Indiana. Circle* 184.

NEW CLOSED-LOOP RECORDER/REPRODUCER for repetitive study of highly transient data, random occurrences, and time-delay application is a completely self-contained system containing amplifiers, precision-frequency power supplies, and blower. It provides selective or simultaneous erase for its 14 analog, FM or PDM record/reproduce channels. It records or reproduces data on continuous magnetic tape loops of variable lengths, ranging from two to 75 feet at tape speeds from 1⅞ through 60 inches-per-second. Contained in a single cabinet, it eliminates the need for the two to three conventional machines previously required to offer comparable versatility. Consolidated Electrodynamics Corp., Pasadena, Cal. Circle 190.

SOLENOID VALVES *for high pressure hydraulic power systems include two-way and three-way valves in both A.C. and D.C. models. Complete, well-arranged information is given, including dimensions, to enable the designer to make his own valve selection in most cases. Waterman Engineering Co., Evanston, Ill. Circle* 159.

PRECISION SEALED LIMIT SWITCHES meet high-shock requirements of MIL-S-901B (Navy). Designed for use on gun mounts and missile launching platforms, switches have an in-line plunger actuator. Compact cylindrical housing contains two single-pole double-throw circuits. All exposed parts are corrosion resistant. Electrically rated for: 5 amps., 115 vac at sea level and 100,000 feet, inductive load. Micro Switch, Freeport, Illinois. Circle 186.

POTENTIOMETER *brochure summarizes key information on lead screw actuated potentiometers; a specification table lists available resistances, terminal types, end settings, power ratings, operating temperatures, and dimensions of the more popular models. Prices included. Bourns Laboratories, Riverside, Cal. Circle* 162.

"THE LIGHTENING EMPIRICIST", a 4-page folder, contains items of interest and value on applications, techniques, and new or improved components in the field of analog computation. George A. Philbrick Researches, Inc., Boston, Mass. Circle 161.

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